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ORIGINAL ARTICLES.

The Upper and Lower Junctions of the Midford Sands at Limpley Stoke, S.E. of Bath.

By Major A. Gorham.

I. Introduction.

BEFORE describing the section at Limpley Stoke I wish to acknowledge the very kind help given to me by Dr. W. D. Lang, F.R.S., Keeper of the Department of Geology in the British Museum (Natural History), who has had the fossils examined and through whose encouragement I am recording the results of an investigation extending over a considerable time.

The Belemnites collected were too imperfect for definite naming: the Ammonites have been examined and identified by Dr. L. F. Spath, F.G.S.; the Lamellibranchs by Mr. L. R. Cox, M.A., F.G.S.; and the Brachiopods by Miss H. M. Muir-Wood, M.Sc., F.G.S.

No previous account has been given of the section here described—indeed, there are but few detailed descriptions of similar sections showing the junction of the Midford Sand with the subjacent Lias. It is desirable, therefore, to give a detailed account of this section of which the beds have been most carefully measured, the fossils collected with the utmost care with regard to their exact horizon, and the species authoritatively determined.

II. The Locality.

The section is situated at the southern end of a north-south outcrop of Lias, which runs through Bathford, and forms the most easterly extension of Lias in Somerset.

The main feature of the neighbourhood is the valley of the River Avon, which cuts a gorge in the lower Oolite and Lias between Bradford-on-Avon and Bath. Its direction is mainly from south to north, and it is joined on its western side, first by the Frome valley at Freshford, and then by that of the Midford brook, at three-quarters of a mile north of Limpley Stoke. The section here described is at the weir of Limpley Stoke, where the gorge is narrowest and the river-bed is 70 feet above sea-level. Most of it has been artificially excavated. If we ascend the hill from this point, we pass in succession through the Midford Sands (*sensu stricto*); the Upper Trigonia Grit and the coral rubble beds; the Doulting beds and Anabacia Limestone, both well developed; the Fullers Earth Clay; and so to the Great Oolite, which caps the hills, with here and there patches of Bradford Clay, Forest Marble, and Cornbrash at elevations of 500–600 feet above sea-level.

Near the River Avon and its tributaries, and especially where the valley becomes broader, the Lias is frequently covered with from 3 feet to 10 feet of gravel—the Mammal Drift of Moore.[1] This may occur as high as the 100-ft. contour, or even slightly higher in some places.

III. STRATIGRAPHY: GENERAL.

In this district the Lower Bathonian Upper Trigonia Grit rests directly with a clear, sharply defined junction, on the Toarcian Midford Sand, which for some six or eight inches below the junction is slightly calcareous and indurated. This junction is exposed in ten sections in the immediate neighbourhood of Limpley Stoke, of which two are natural, and the rest in quarries, or cuttings for railways, roads, or canals. One of the two natural exposures lies within a few yards of the house at Tucking Mill, where " lived William Smith, the Father of English Geology ".[2] He first named the " Midford Sands ", and it may be that the contemplation of that sharp junction of the soft sand with the solid grit had not a little to do with the discoveries he first made. The top beds of the sand have undoubtedly been denuded and point to a time when the district was dry land. Subsequent subsidence, extending over a wide area in Somerset, let down the Midford Sand land surface to below sea-level, and flooded it with a clear, and probably shallow, sea, on whose floor of golden Midford Sand, the Upper Trigonia Grit with its wonderful assemblage of fossils was laid down.

The indurated topmost portion of the Midford Sand is sometimes firmly cemented to the Upper Trigonia Grit, and contains rolled fragments of ammonites, some of which Dr. Spath has identified as *Dumortieria* and *Pleydellia*. Besides these derived fossils I have collected *Grammoceratoides* lying in the plane of stratification in the same bed and obviously contemporaneous with the deposit.

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[1] *Bath Natural Hist. and Antiquarian Field Club*, vol. ii, 1870, p. 48.

NOTE.—This year (1929) excavations have been made in the river bed for foundations for the bridge at Limpley Stoke, from which I have collected a large number of blackened bones. In the gravel at a depth of 3 ft. 6 in. were found the radius and ulna of an ox, *Bos* sp., also a large cervical vertebra which probably represents *Bos primigenius*. These were kindly identified for me by Miss D. M. A. Bate, at the British Museum (Natural History).

[2] See mural tablet on wall of house.

The Midford Sands are part of the Toarcian, or Upper Lias, and are here treated of as a separate entity only to emphasize their junction with the subjacent beds of the Upper Lias. The late Mr. S. S. Buckman, while insisting on their identity with parts of the Upper Lias, applied d'Orbigny's inclusive term " Toarcian ". Thus : " The following changes among others, namely, the abolition of the dividing-line now drawn between Upper Lias and " Midford Sands ", which is erroneous, and the merging of these two divisions with one—Lower Toarcian." [1]

The thickness of the Midford Sands at Limpley Stoke, namely, 70 feet, is easily estimated, as the upper junction is exposed in the Kennet and Avon Canal cutting only 200 yards distant horizontally from the lower junction at the weir. Heights can be measured with great accuracy by using Bench Marks, and the splendid practical contour afforded by the canal : It then only remains to observe the direction (150° true) and the dip of the strata (2½°). Hence the thickness—70 feet—is obtained.

We have seen that the upper junction is seldom exposed, but the lower junction with the subjacent Upper Lias is only seen in artificial sections. Moore remarks on the thinness of the Upper Lias and other Mesozoic rocks in the Somerset and South Wales coal basin [2] ; and referring to the Camerton district he wrote : " No section of the Upper Lias is uncovered in this district and whenever present it appears to be thin.[3]

Possibly there was a great bay in the Liassic seas, bounded southward by the Mendip uplift, westward by a continuation of high land into South Wales, and northward by land connecting the South Wales heights and the Malvern uplift ; the bay was nearly land-locked in later times by elevation of the sea bottom towards the east, as this area is considered to have been cut off from the Cotteswold area between Upper Lias (Toarcian) time and that of the Upper Trigonia Grit (Lower Bathonian).[4]

IV. THE DETAILED SECTION.

Note.—The beds are numbered from below, upwards ; and lettered from above downwards. Letters followed by a number after the name of any fossil, refer to specimens presented by the author to the British Museum, and are the Museum Register Number of the Specimen.

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[1] S. S. Buckman, *Quart. Journ. Geol. Soc.*, vol. xlv, 1889, p. 470.

[2] Moore, *Quart. Journ. Geol. Soc.*, vol. xxiii, 1867, p. 476.

[3] Loc. cit., p. 474.

[4] S. S. Buckman, *Proc. Cotteswold Nat. Field Club*, vol. ix, 1890, p. 374.

Lower Oolite (Lower Bathonian, or Vesulian).

Zone of *Parkinsonia parkinsoni*, sub-zone of *Garantiana garantiana.*

18. 4 ft.–8 ft. Upper Trigonia Grit.

Non-sequence.

Upper Lias (Toarcian).

Zones of *Phlyseogrammoceras* to *Pseudogrammoceras.*

Midford Sands.

17. 5 in.–8 in. Indurated, somewhat calcareous sandstone containing casts of *Grammoceratoides*, and rolled fragments of *Pleydellia, Dumortieria,* with *Belemnites acutus.*

16. 70 feet. Fine yellow micaceous sandstone with thicker beds and a few indurated bands towards the base.

Pseudogrammoceras.
Stomechinus bigranularis Lamarck (? lying at base).

Upper Lias below the Midford Sands.

15. A. 6 inches. Red Marly sandstone.

Phlyseogrammoceras sp.
Pseudogrammoceras spp.
Belemnites spp.
Rhynchonella spp.
Rhynchonella jurensis Quenstedt.

Zone of *Grammoceras striatulum.*

14. B. 3½ in. Dark grey, slightly oolitic marlstone weathering reddish brown with black surfaces to natural fractures.

Pseudogrammoceras spp. numerous.
Lytoceras sp.
Harpoceras sp.
Belemnites sp.
Velata velata Goldfuss.
Rhynchonella jurensis Quenstedt.
Stolmorhynchia sp. B. 51664.
½ in. Friable, fragmentary, iron-shot parting.

Zone of *Hildoceras bifrons.*

13. C. 7 in. Hard, compact, blue-hearted, highly oolitic limestone, with orange-coloured fossils and oolitic grains; fossils fragmentary and embedded at all angles.

Hildoceras spp.
Hildoceratoides levisoni Wright non Simpson.
Hildaites sp.
Harpoceras cf. *elegans* Reynes non Sow.

Harpoceras spp. auctt.
Dactylioceras spp. juv. numerous.
Dactylioceras athleticum Simpson.
Catacoeloceras sp. juv. ind.
Lytoceras cornucopia Young and Bird, auctt.
Nautilus sp.
Belemnites spp. some large.
Rhynchonella moorei Davidson.

Zone of *Harpoceras falciferum.*

12. D. 8 in. Compact, tough, greyish-white, marly limestone.

Harpoceras falciferum.
Harpoceras spp. juv. ind. numerous.
cf. Hildaites sp.
Dactylioceras sp.
Placunopsis sp.
Plagiostoma punctata Sow.
Corbula sp.
Serpula sp.

11. E. 6 in. Clay, stiff, brownish-blue, conchoidal.

Harpoceras falciferum. Large weathered specimens.
Lytoceras sp.
Dactylioceras sp. juv.
Belemnites spp. small, thin, numerous.
Fragment Saurian bone ?

10. F. 6 in.–8 in. Limestone, somewhat marly, greyish-white.

Dactylioceras sp.
Harpoceras, large fragments.

9. G. 4 in.– 7 in. Limestone, similar to above with a few included pebbles.

Harpoceras spp. juv. ind.
Dactylioceras sp.
Catacoeloceras sp.
Belemnites spp. larger at base.
Aporrhais sp.
Lobothyris punctata J. Sow. B.·51667.
Gasteropods a few small.
Lignite.

8. H. 3½ in.–4½ in. Dark grey, and reddish-brown grit, decomposed and sandy at base, with many included pebbles of clay ironstone, and crowded with *Belemnites* in places. Top bed planed off and capped with ¼ in. of clay ironstone which is bored with *Lithodomus.*

CEPHALOPODA.

Harpoceras sp.
Dactylioceras sp.
Dactylioceras sp. fine ribbed.
Amaltheus sp. (clay ironstone pebble).

GASTEROPODA.

Pleurotomaria princeps Koch and Dunker. G. 48533.
Pleurotomaria princeps Koch and Dunker. G. 48534.
Pleurotomaria princeps sp. indet, acutely keeled.
Loxonema sp.
cf. Procerithium gracilispina Crossman. G. 48535.
Straparollus nov. sp. (1). G. 48529.
Straparollus nov. sp. (2). G. 48530.
Straporollus nov. sp. (2). G. 48531.
Straparollus cf. dunkeri Moore. G. 48532.

LAMELLIBRANCHIATA.

Placunopsis sp. indet.
Mactromya sp. indet.
Ostrea sp. indet.
Velata velata Goldfuss. L. 52524.
Velata sp. indet.
Lima (*Ctenoides*) *succincta* Schlotheim.
Chlamys nov. sp. cf. *Ch. substriata* Roemer. L. 52491.
Chlamys oequivalvis J. Sowerby.
Chlamys textoria Schlotheim.
Chlamys prisca Schlotheim.
Chlamys calva Goldfuss.
Lithophaga sp. indet.
Gryphera gigantea J. Sowerby.
Entolium frontalis Dumortier.

BRACHIOPODA.

Crania sp.
Rhynchonella sp. (1).
Rhynchonella sp. (2).
cf. Stolmorhynchia bouchardi Davidson sp.
Homoeorhynchia acuta Sow. sp.
Gibbirhynchia media, Sow. sp.
Gibbirhynchia Gibbosa S. S. Buckman.
Aulacothyris resupinata, Sow. sp.
Tetrarhynchia northamptonensis Walker sp.
Tetrarhynchia tetrahedra Sowerby sp.
Zeilleria spp. B. 52670.

VERMES.

Serpula tricarinata Sow., attached to *Belemnite.*
Serpula gordialis Schlotheim } both in same block with *Lima*
Serpula sp. } *succincta.*
Non-sequence.

MIDDLE LIAS.

Zone of *Amaltheus margaritatus.*

7. J. 10 ft. Clay, dark blue when wet, light grey when dry; laminated and iron-shot, with hollow, irony lumps in lower part. No yield.

6. K. 6 in. Marl-stone, soft, impersistent, carrot-red.
Androgynoceras sp.
Gervillia crassa Buckman.
Modiolus cf. numismalis Oppel.
Modiolus cf. *minimus* J. Sowerby.

5. L. 3 ft. Clay, dark blue.
No yield.

4. M. 2 ft. Marl-stone, weathering brick-red with minute, comminuted, white shell-remains.
Modiolus sp.
Gryphaea gigantoea J. Sowerby.

3. N. 8 in. Hard, grey grit, weathering red, and splitting into slabs.
Fish-remains.

CEPHALOPODA.

Amaltheus sp. juv.

LAMELLIBRANCHIATA.

Unicardium subglobosum Tate (– *U. globusum* Moore).
Lima (Mantellum) duplicata J. de C. Sowerby.
Lima (Ctenoides) succinata Schlotheim ?
Oxytoma inequivalve J. Sowerby.
Ceratomya petricosa Simpson. L. 52492.
Chlamys (Aequipecten) aequivalvis.
Gryphaea sp. indet.

BRACHIOPODA.

Lingula beani Phillips.
Lingula sacculus Chapuis and Dewalque. B. 51663.

2. O. 6 in. Clay, weathering yellow.
No yield.

1. P. 2½ in. Pecten Bed.
Aequipecten aequivalvis J. Sowerby.
Belemnites sp.
Below this is marl-stone and dark blue and brown clay for some 15 feet, when we come to marl-stone with *Liparoceras capricornus.*

V. REMARKS ON THE SECTION.

Bed P. The Pecten Bed.—This bed has certain peculiarities, and affords material for speculation: it is composed of *Aequipecten aequivalvis.* The valves lie packed as closely as possible, and are all convex-side uppermost. Taking the average life of a Pecten of average size (i.e. about 2¼ inches from the hinge to the front edge) as being twenty years, and the number of shells in an inch of section as sixteen (which must be divided by two as there were two valves): the period during which these Pectens lived is 160 years, while the period during which an inch of section was deposited may be very much greater, as a shell was not necessarily covered over by another, or part of another, immediately after the Pecten died.

From these, and other, considerations a Pecten bed 3 inches thick tells us of a period during which there was a fairly shallow sea with moderate currents, composed of clear water, somewhat charged with calcium carbonate in solution, and supporting countless millions of Pectens over a period of not less than 500 years, and probably more than 1,000 years.

This bed is on the same horizon as the uppermost Pecten Bed of Moore's Oaks Lane Section (some 8 miles from Limpley Stoke) and may be continuous with it.[1] It would seem that some prominence should be given to these beds, for they at least mark definite sea-floors and genuine stratigraphical horizons. If the period of their formation was very great, then the period of quiescence was very great; but if the period was short, then they do all the more mark absolutely contemporaneous horizons, or datum lines, over all the area in which a bed is continuous.

Bed N.—This bed is interesting as being the only one to furnish *Lingulidae.*

Bed H.—This bed appears to mark the first arrival of a change of oceanic conditions. The clay J, upon which it rests, seems to be the lower part of Middle Lias of Domerian age. It may here be remembered that if the zone of *spinatum* is represented at all in the Somerset Coal-basin area, yet the actual fossil *Paltopleuroceras spinatum* does not appear to have been collected in the district. In Bed H we have found, on the one hand, a mixture of derived fossils, and specially the numerous flattened and water-worn clay-ironstone pebbles, one of which is an ammonite cast (*Amaltheus*); on the other hand, the numerous Gasteropods do not appear to be derived, and point to the proximity of coastal conditions; and the *Rhynchonellae* are frequently very perfect and sometimes occur in nests. This bed has furnished the rare gasteropod *Straparollus*, two new species being recorded. Both coarse and fine-ribbed *Dactylioids* occur, and bed appears to be first representative of Upper Liassic conditions, resting on denuded clay of Middle Lias age.

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[1] Moore, *Proc. Som. Arch. and Nat. Hist. Soc.*, vol. xiii, 1867, p. 152.

The Beds F and G vary in thickness, and are probably one bed with a distinct, though very uneven, parting.

The Bed C is the most distinctive lithically, with its crowded ammonites and oolitic grains, all orange-coloured, against the blue background of limestone. It probably illustrates the transportation and accumulation of ammonite shells, the *Hildoceratidae* and *Dactylioceratidae* being perhaps the principal contemporary ammonites, as they are the most perfect.

In the sand 2 feet above A there is an indurated band, from which I obtained an imperfect and crystalline cast of *Pseudogrammoceras*, which also was found 8 feet above the base of the Midford Sand.

The Generic Position and Phylogeny of Some Jurassic Arcidae.

By W. J. Arkell, M.A., D.Phil., B.Sc.

(PLATES XIV–XVI.)

Introduction.
I. Parallelodon and Beushausenia.
II. Grammatodon.
III. Conclusions regarding Nomenclature.
IV. The Origin of Parallelodon.
V. Some Cretaceous and Tertiary Genera.
VI. Jurassic Species of Parallelodon and Sub-Genera.
VII. Navicula and Eonavicula.
VIII. Species of Eonavicula.
IX. The Origin of Eonavicula.
X. General Remarks.

Introduction

The following observations are the result of working over the Middle Jurassic Arcidae with a view to monographic treatment of the Corallian and Bathonian species. The monographs must of necessity be slow in appearing, and in any case they are not the place to discuss the broader conclusions to which the investigations have led. The family is one full of interest from an evolutionary point of view, but an exceptionally involved maze of controversial matter, chiefly concerning nomenclature, by which the Arcidae have been burdened, has obscured the features of interest and the phylogeny.

Where so many opinions have been offered before, and so many palaeontologists have contested some of the points at issue, it might be thought that little could be said that is new. Nevertheless, the statements of previous writers would often have been different had they been dealing with the Arcas of more geological formations, or had they been in possession of more specimens, and I need not apologise for offering an unbiassed review of previous work and attempting to straighten out the tangle of divergent opinions. The systematic working over of this material has crystallized into more tangible form a number of ideas only hazily suggested by their authors, or buried as footnotes in monographs. In addition, however, it has led to some conclusions regarding the ancestry of the modern Arcidae, which, so far as I am aware, have not appeared before in print, although it might be rash to claim them as new.

Before proceeding I must thank Dr. F. L. Kitchin, F.R.S., Mr. C. P. Chatwin, and Mr. L. R. Cox for their ever-ready help in facilitating my access to the national collections, and for their kindness and advice while I have been at work. Also Mr. Henry Woods, F.R.S., for permission to reproduce some figures from the first plate in his Monograph of the Cretaceous Lamellibranchia.

I. PARALLELODON AND BEUSHAUSENIA.

The naming of fossil Arcidae has been a subject of difficulty with palaeontologists since the earliest time. Even one hundred years ago, when there were only two genera, *Arca* and *Cucullaea*, into which to apportion the Jurassic species, we find many Cucullaeas identified as *Arca* and Arcas as *Cucullaea*.[1]

Previous to 1850, however, there was rarely mention of any genus in the Jurassic rocks other than *Arca* and *Cucullaea*, and the matter was still one of comparative simplicity.

In 1853 Morris and Lycett, in their Palaeontographical Society's monograph on the Great Oolite Mollusca, made known J. Buckman's genus *Macrodon*, born obscurely in 1845 in an appendix to the second edition of Murchison's *Outline of the Geology of Cheltenham*.[2] The genotype was *M. rugosus*, a large elongate shell, with a long, heavy, wide hinge plate, bearing three elongate posterior teeth, roughly parallel to the hinge margin, but diverging somewhat in a ventral direction, running from near the umbones almost to the posterior end, and seven short, oblique anterior teeth, directed upwards and outwards. (Text-fig. 1 and Plate XIV, Figs. 1–4.)

This type of dentition is common among Arcidae throughout the Jurassic, but Morris and Lycett had no clear conception of the generic characters. In their monograph they assigned only one species to the genus, a shell from the Great Oolite limestones of Minchinhampton,[3] describing all the other species not referable to *Cucullaea*, as *Arca*. They identified their *Macrodon* with *Cucullaea hirsonensis* d'Archiac, from the Bathonian of the Aisne. It is of very different appearance from d'Archiac's species, which, although a *Macrodon*, lacks the terminal, alar prolongation of the posterior end of the hinge-line, and belongs to a different sub-genus. Morris and Lycett's

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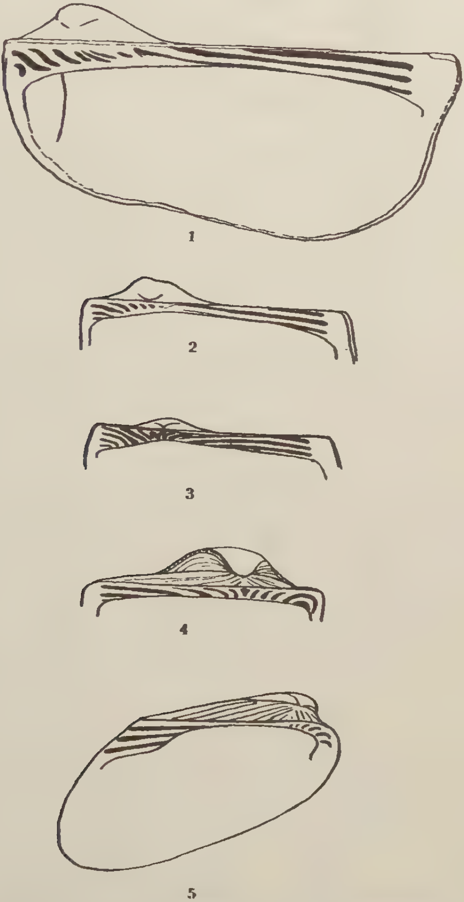
[1] E.g. 1829, Phillips, in *The Geology of Yorkshire*, figures as *Cucullaea pectinata* on pl. iii, fig. 23, what we now call a *Barbatia*, and as *Cucullaea concinna* on pl. v, fig. 5, what we now call a *Grammatodon* (both Arcas in the old sense of the word).

[2] p. 98, and pl. v, fig. v.

[3] 1853, " Mon. Mollusca from the Great Oolite," *Pal. Soc.*, p. 49, pl. v, figs. 1, 1*a*, 1*b*.

M. hirsonensis is specifically indistinguishable, however, from the genotype, *M. rugosus* Buckman, which came from the Upper Inferior Oolite of Leckhampton Hill, i.e. Vesulian (= Lower Bathonian). Topotypes from both localities may be compared in the British Museum, and no specific distinctions can be drawn.



Figs. 1–4.—Hinges of Parallelodontinae and an Ambonychiid. 1, *Parallelodon rugosum*; 2, *P.* (*Beushausenia*) *buckmani*; 3, *P.* (*Beushausenia*) *keyserlingii*; 4, *P.* (*Grammatodon*) *carinatum* (after Woods); 5, *Cypricardites* (Ambonychiidae). (All the figures reduced nearly half).

An investigation of Morris and Lycett's type specimens in the Geological Survey Museum shows that, of the other species described by them as *Arca*, three belong to *Macrodon* as defined by them: one, *A. kilverti* Mor. and Lyc., seems to be a young individual of

Macrodon rugosum itself; a second, *Arca rudis* (Sow.) belongs to the same alate group as the type species (Plate XIV, Fig. 5), the other, *A. aemula* var. *transversa* Mor. and Lyc., to the same genus but another, non-alate, sub-genus, exemplified by "*Cucullaea*" *hirsonensis* d'Archiac. Of their other Arcas, one (*A. tenuitexta*) is an *Isoarca*, three (*A. pulchra* Sow., *A. prattii* Mor. and Lyc., and *A. prattii* var. *rugosa* Mor. and Lyc.) are Barbatias, while the remainder (*A. eudesii* Mor. and Lyc., *A. minuta* Sow., and *A. aemula* Mor. and Lyc. non Phil.) are quite different from any of these genera and will be dealt with later.

Unknown to Buckman in 1845, his new generic name *Macrodon* had been occupied three years earlier by Müller for a genus of fishes. To rectify this, Meek and Worthen in 1866 suggested replacing *Macrodon* Buckman by a new name, *Parallelodon*, as follows[1]: "Should it be thought desirable to change the name of this extinct genus, in consequence of the fact that Müller had used it for a genus of fishes in 1842, it might be called *Parallelodon*, from its elongated parallel posterior teeth." Meek and Worthen wrote this on the assumption that the Jurassic genus *Macrodon* was identical with some Devonian and Carboniferous shells which they were describing, although for these they continued to use the name *Macrodon*.

In 1897 Wheelton Hind, following de Koninck (1885) and Whidborne (1892), adopted *Parallelodon* in his Monograph of the Carboniferous Lamellibranchia for a large number of Carboniferous species, and discussed his reasons.[2] He considered the Jurassic genus to differ from the Carboniferous because "*Macrodon* has not the diverging sub-parallel elongate posterior teeth of *Parallelodon* and the anterior teeth are fewer in the latter genus. The anterior adductor muscle-scar in *Parallelodon* has no sharp, prone edge" (loc. cit., p. 128). But, as Mr. L. R. Cox has recently pointed out,[3] if the two genera are different, it is the Carboniferous genus which must receive a new name, for *Parallelodon* was only a substitution name for *Macrodon*, and therefore the genotype of *Parallelodon* must be the genotype of *Macrodon*, i.e. *M. rugosum* Buckman = *M. hirsonensis* Mor. and Lyc. non d'Archiac, from the Vesulian and Bathonian. (It should be noted that the example of *Parallelodon* cited by Mr. Cox in his paper, described as *Parallelodon dorsetensis* Cox, is a shell with a number of short oblique posterior as well as anterior teeth, a sharp carina and radial sulci behind it, and umbones obliquely flattened on their anterior side, different in both form and dentition from the true *Parallelodon*) (see infra).

The question whether the Jurassic *Parallelodon* is identical with the Lower Carboniferous and Upper Devonian forms, at first sight very similar, is an important one from an evolutionary point of view. In the passage just quoted, Wheelton Hind gives three reasons for considering them distinct: he states that (1) the posterior, elongate, diverging, sub-parallel teeth of the Carboniferous forms are not found in the Jurassic genus, (2) the Carboniferous forms have fewer anterior teeth than those in the Jurassic, and (3) they lack the projecting anterior adductor muscle attachment.

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[1] 1866, *Proc. Chicago Acad. Sci.*, vol. i, p. 17.

[2] 1897, "Mon. Carb. Lamell.," *Pal. Soc.*, vol. i, pp. 125-130

[3] 1925, *Proc. Dorset Field Club*, vol. xlvi, p. 127.

The first distinction can at once be dismissed; Wheelton Hind evidently obtained his idea of the posterior part of the hinge of *Macrodon* from J. Buckman's imperfect description, which he quotes in the earlier part of the same paragraph. Actually, most of the Jurassic species have "from two to four diverging, sub-parallel elongate teeth" which do *not* reach the end of the hinge line.

The second distinction, based on the number of the anterior oblique teeth, is quite untrustworthy, since the number of these teeth varies in different species both in the Carboniferous and in the Jurassic. Although *P. rugosum* (Buckman) has seven anterior teeth distinctly visible, the inner ones becoming increasingly small, in many other species the inner three to five teeth are so small that they are mere granules easily overlooked. *P. buckmani* from the Lower Lias, for instance, has only three or four real teeth properly so called, behind which are a few granular vestiges (Pl. XIV, Fig. 8 and Text-fig. 2). In *P. aemulum* (Phil.), from the Corallian, the number of visible teeth in a perfectly cleaned specimen is four, and the same is true of the Liassic *P. banburyensis*. These are the numbers common in the Carboniferous species, but the hinge is rarely seen sufficiently well in specimens embedded in Carboniferous Limestone matrix for the granules beneath the umbones to be visible. Doubtless these granules, which represent the small, inner anterior teeth, exceptionally well developed in the genotype, are also present in the Palaeozoic forms, for even among the Jurassic species it is only in the best specimens of certain species that they can be discerned.

Hall, in describing *Macrodon hamiltoniae* from the Hamilton Group (Uppermost Middle Devonian) of New York State, wrote, "the hinge structure has the usual characteristics of the genus," which he defines on an earlier page as follows: "Hinge furnished with several (sometimes eight) small diverging teeth beneath the beak and by from two to four lateral teeth situated near the posterior extremity of the cardinal line."[1]

The hinge characters, then, are insufficient to distinguish the Jurassic *Parallelodon* (*Macrodon*) from the species so named in the Carboniferous and Devonian.

The third distinction mentioned by Wheelton Hind is based on the attachment of the anterior adductor muscle. In the genotype,

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[1] 1885, "Geol. Surv. State of N.Y.," *Palaeontology*, vol. v, part i, "Lamell. of the Upper Helderberg, Hamilton, Portage and Chemung Groups," pp. 350, xxviii; see also pl. li, figs. 1–16.

P. rugosum, this muscle is attached to a conspicuous raised boss, formed by a local thickening of the inside of the shell (seen in Pl. XIV, Figs. 1 and 2), and this may be seen in other species, such as *P. aemulum* (Phil.). In others, however, such as *P. buckmani*, equally typical in every other respect, this thickening is much less developed, in fact barely noticeable; while in *Grammatodon*, which as we shall see can only be regarded as a sub-genus of *Parallelodon*, there is always total absence of any such thickening. In any case, there is never a " sharp prone edge " to the muscle scars of any *Parallelodon*, as suggested by Wheelton Hind, this feature being peculiar to the posterior scar of *Cucullaea*.

Taking into consideration, then, the truly remarkable resemblance in form and all shell features between the Devonian, Carboniferous, and Jurassic Parallelodons, there seems to be no justification for separating them under different genera, as has usually been done. With Wheelton Hind, " I am strongly of the opinion that the custom of inventing new names for every form of a family which happens to occur in a different system of strata will be found to be based on faulty observation, and that genera and even species survived for much longer periods than is at present recognized " (loc. cit., 1897, p. 128). At the same time, I would go further and put this precept into practice by reuniting the Palaeozoic and Jurassic Parallelodons.

Sub-genera worthy of differentiation there may be. But the naming of these should not obscure the salient feature of interest, the probability of a direct line of descent.

Wheelton Hind divides the Carboniferous Parallelodons into three groups :—

Group A. With concentric, widely-separated, imbricated lamellae, exemplified by *P. squamifer*.

Group B. With reticulate ornament, exemplified by *P. cancellatus* and *P. reticulatus*.

Group C. Surface smooth, with concentric, or with microscopic, lines only, exemplified by *P. obtusus*.

Of these, the first group (A) does not resemble any species found in the Jurassic, and is presumably the most primitive. The other two groups contain a number of species extraordinarily similar to some of those in the Jurassic. The division into groups B and C on the grounds employed by Wheelton Hind, however, would seem to be based on characters too trivial to be of much value. Apart from such details of ornament, the species may be divided into (1) those having an alar prolongation of the posterior end of the hinge-line, and (2) those in which the posterior end of the hinge-line is not terminal. Into the first group fall *P. obtusus* and *P. divisus* and ? *P. walciodorensis* (figured Wheelton Hind, op. cit., pl. xii, figs. 2–6, 9; pl. xiv, figs. 1–3; pl. xiii, figs. 11–14; and pl. x, figs. 13–15); into the second fall most of the other species not included in the *squamifer* group.

These two groups are clearly distinguishable, not only in the Carboniferous and Devonian, but also throughout the Jurassic, system. The alate group, to which the genotype, *P. rugosum* belongs, is considerably the poorer in species, but it persisted as late as the Kimeridgian period.

The non-alate group is of such distinctive external appearance that it is worthy of sub-generic differentiation. A name already exists for it, *Beushausenia* Cossmann,[1] suggested as a substitute for *Macrodus* Beushausen, which in turn was intended to replace *Macrodon* Buckman but was not sufficiently different from the original to be valid. *Beushausenia*, however, is not merely a synonym of *Parallelodon*, for in proposing it Cossmann named "*Cucullaea*" *hirsonensis* d'Archiac as type. Reference to d'Archiac's figure makes it at once apparent that this species is not the same as Morris and Lycett's *Macrodon hirsonensis* (which I have already mentioned is identical with the genotype, *M. rugosum*) but that it is one of the non-alate group.

Species of *Beushausenia* are so numerous in the Jurassic rocks that specimens have often been obtained which show the detailed arrangement of the teeth (e.g. Pl. XIV, Figs. 8 and 9). When the central part of the hinge-plate is well preserved, the long posterior teeth can be seen to originate beneath the umbones on the ventral edge of the hinge-plate, and then to diverge dorsally away from the umbones, finally running parallel with the hinge line or even bending round so as to diverge ventrally from it (as in the genotype, Pl. XIV, Figs. 1 and 2). The long, often ventrally divergent, posterior teeth are, therefore, of truly taxodont origin, and although they have become much modified, they arise in the same way as the more homogeneous, serial, dorsally-divergent, short teeth of *Barbatia* or any of the other Arcidae.

II. GRAMMATODON.

Six years before Meek and Worthen proposed the name *Parallelodon*, Meek founded the genus *Grammatodon*.[2] The genotype of this was *Arca* (*Cucullaea*) *inornata* Meek and Hayden, from the Lower Jurassic of the Black Hills, Dakota. Unfortunately, the original figure is bad and does not indicate all the characters, although it shows at a glance that *Grammatodon* is shorter and more oval in shape than *Parallelodon*. Meek appended an adequate description, however, stating that *Grammatodon* (1) has the same dentition as *Macrodon* (*Parallelodon*) but differs (2) by being proportionately much shorter. (3) by having more mesial umbones (4) by having its pallial margin smooth and closed instead of crenulated and gaping, (5) by the absence of any "ridge or prominence" for the attachment of either adductor muscle. He added that in his opinion it may be only a sub-genus of *Macrodon* (*Parallelodon*). Twelve years later Meek reiterated this opinion,[1] Stoticzka having written five years previously, "I doubt whether there is sufficient ground for even sub-generically separating the form in question.[2]

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[1] 1897, *Revue critique de Paléozoologie*, p. 93.

[2] 1860, *Proc. Acad. Nat. Sci., Philadelphia*, p. 51; and 1864, in Meek and Hayden, *Smithson. Contrib.*, vol. xiv, No. 172, p. 89, pl. iii, fig. 9.

In most subsequent publications the use of the name *Grammatodon* has not been reserved for shells conforming to Meek's description. The Geological Survey in some of their latest memoirs refer Parallelodons such as *P. keyserlingii* to *Grammatodon*,[3] and also such forms as *Arca quadrisulcata* Sow.,[4] which we shall see should be assigned to quite a different genus.

The reason for these identifications may be traced to an opinion expressed by Mr. Henry Woods that *Grammatodon* and *Parallelodon* are identical.[5] In this he is followed by Mlle. Gillet, who in her comprehensive work on the Neocomian lamellibranchs includes *Parallelodon* and its synonyms as synonyms of *Grammatodon*, without explanation.[6] But from what has just been summarized of Meek's description of *Grammatodon*, I think it must be granted that it is not identical with *Parallelodon*, although if we base our genera strictly upon dentition we can only separate it sub-generically, as did its founder.

The type species, *G. inornatum*, is so little like other Jurassic Parallelodons that Meek and Hayden first described it as a *Cucullaea*. It is, in fact, a *Cucullaea* externally, with the dentition of *Parallelodon*, but placed upon a hinge-plate much shorter than any true Jurassic *Parallelodon* (compare Figs. 1, 2, 3, 4 and see Pl. XV). Meek and Hayden describe its surface as "entirely destitute of radiating striae, though there may be very fine radiating lines where the surface is well preserved". Other species, however, which must certainly be grouped with it, are ribbed and striated radially, either on the posterior and anterior ends only, or all over the shell, while in some the left valve is more strongly ribbed than the right.

Numerous typical species occur in the Oxfordian and Corallian, exemplified by "*Cucullaea*" *concinna* Phillips, the hinge of which has been beautifully figured by de Loriol [7] (Pl. XV, Fig. 2). In the Cretaceous some species, such as *P.* (*G.*) *securis* (Leym.), ribbed more strongly on the left valve than on the right, are little different from their predecessors in the Lower Lias (e.g. *P.* (*G.*) *inaequivalvis* Goldf. sp., Pl. XV, Fig. 1).

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[1] 1876, *Report on Invert. Cretaceous, and Tertiary Fossils of Upper Missour* , p. 85.

[2] 1871, "Cretaceous Fauna S. India, Pelecypoda," *Pal. Indica*, p. 336.

[3] 1925, "Geol. Country Around Golspie, Sutherlandshire," *Mem. Geol. Surv.*, pp. 101, 102.

[4] 1923, "The Concealed Mesozoic Rocks in Kent," *Mem. Geol. Surv.*, p. 95.

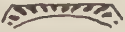
[5] 1899, "Note on the Genus *Grammatodon*," *Ann. Mag. Nat. Hist.*, series vii, vol. iii, pp. 47–8.

[6] 1924, *Mém. Soc. Géol. France*, new series, vol. i, p. 15.

[7] 1896, "Oxfordian sup. moy. Jura Bernois," *Mém. Soc. Pal. Suisse*, pl. xiv, figs. 5–11, sub. *Macrodon*.

Judged by external characters, *Grammatodon* is often indistinguishable from *Cucullaea.* It is therefore not surprising to find that the hinge has more in common with that of *Cucullaea* than is at first sight apparent.

When we examine the hinge of typical species of *Grammatodon* (Pl. XV), we find that the origin of the elongate posterior teeth on the ventral edge of the hinge plate, already remarked in certain species of *Beushausenia*, is particularly well shown. In the young stages of certain species of *Cucullaea* the teeth are seen to have a similar origin, as has been shown by Mr. Woods in figures of the Cretaceous *Cucullaea glabra* Park.[1] At first there is a series of short, dorsally-divergent, sub-equal teeth, similar to those of *Glycimeris*, *Limopsis*, or *Barbatia.* Later the outer teeth, both posterior and anterior, become elongate and curve outward, so as to run parallel to the hinge margin (Figs. 6–8).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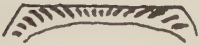
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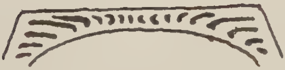
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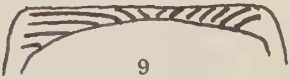
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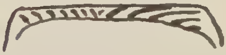
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Figs. 6–10.—Comparison of the hinge of *Cucullaea* and *Grammatodon.*

Figs 6–8.—Young stages of *Cucullaea glabra* Park. from the Cretaceous (after Woods, loc. cit., pl. xi, figs. 10–12) (6 L. valve, 7 and 8 R. valves).

Figs. 9–10.—L. and R. valves of *Grammatodon concinnum* (Phil.) (after figures by de Loriol).

The only difference is that in *Grammatodon* the anterior teeth remain short, while the posterior teeth develop like those of *Cucullaea* (Figs. 9, 10). In *Parallelodon* and *Beushausenia* the elongation is carried still farther, progressively with an attenuation of the whole shell, until the posterior teeth pass the parallel stage and begin to diverge ventrally towards the posterior end of the hinge plate.

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[1] 1899, "Mon. Cretaceous Lamell.," *Pal. Soc.*, vol. i, pl. xi, figs. 10–12.

Nevertheless, *Parallelodon*, *Beushausenia*, and *Grammatodon* are the most closely bound together by their dental characters, in that while their posterior teeth become elongate as in *Cucullaea*, their anterior teeth remain short.

III. CONCLUSIONS REGARDING NOMENCLATURE.

In view of what has been said, I submit that, basing our classification primarily upon dentition, *Parallelodon*, *Beushausenia*, and *Grammatodon* should be regarded as sub-genera of a single genus, having essentially the same dentition but distinct shell characters. It remains to decide which name should take generic rank.

Beushausenia may be ruled out at once, being the last of the three names to be proposed.

Grammatodon has priority by six years over *Parallelodon as a name.*

Parallelodon was only a substitution name for *Macrodon*, which has priority by fifteen years over *Grammatodon as a genus.*

In view of this, and considering its earlier occurrence (the Devonian as compared with the Trias) I favour the retention of *Parallelodon* as the generic name, the genus having been described and figured (under the name of *Macrodon*) fifteen years before *Grammatodon* was heard of as a name or separated by means of its teeth and posterior muscle attachment from *Cucullaea*.

IV. THE ORIGIN OF PARALLELODON.

The hinge characters and shell features of *Parallelodon* were already fully developed in the Middle Devonian. Only one species is known from the British Devonian,[1] but several have been figured from other countries, especially North America. The origin of the characteristic dentition before this period is a matter of some interest, into which we may briefly digress.

First, to recapitulate the features which especially characterize this dentition, we must seek in the Lower Palaeozoic for a hinge-plate bearing from three to seven short, oblique anterior teeth, and three elongate posterior teeth, running almost parallel to the hinge margin, or diverging from it ventrally in a posterior direction.

These features are met with in the genus *Cypricardites* Conrad,[2] which ranges from the Ordovician to the Devonian (Fig. 5). The only difference is that the posterior teeth are shorter and do not begin so near the umbones as in *Parallelodon*. The form of the shell is more tapering towards the anterior than in most *Parallelodons*, but this shape is closely approached by the sub-genus *Catella* Healey of the Trias and Lias (see p. 612). *Cypricardites*, moreover, has the deep, wide, striated ligament area of *Parallelodon*. That the two were descended from a common stock can scarcely be doubted; but if *Parallelodon* actually developed from *Cypricardites*, it did so in the Silurian period or earlier, and *Cypricardites* survived as an independent genus alongside *Parallelodon* into the Devonian.

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[1] 1892, Whidborne, "Mon. Dev. Fauna of S. England," *Mon. Pal. Soc.*, vol. ii, p. 39, pl. i, fig. 1.

[2] 1841, *Annual Rep. on the Pal. of New York*, p. 41 ; synonyms, *Megalomus* Hall, 1852, *Palaearca* Hall, 1858, *Cyrtodonta* Billings, 1858.

The systematic position of *Cypricardites* is of considerable importance from an evolutionary point of view. While Hall, in naming it *Palaearca*, suggested affinity with some of the Arcidae, it was clearly *Parallelodon* which he had in mind, for there is no resemblance in the dentition to that of the other Arcidae.

Zittel classes it with the Ambonychiidae, between the Pteriidae and the Pinnidae, at the same time remarking that it may perhaps belong with the Taxodonta.[1] Other Lower Palaeozoic genera of the Ambonychiidae, such as *Vanuxemia* and *Byssonychia* (figured by Zittel, loc. cit., Figs. 755–6) have a similar plan of dentition, but the shape of some of them links them up with the Pteriidae. In this connection the suggestive shape of the large a late Parallelodons (Pl. XIV, Figs. 3–7) may not be without significance as also the occurrence of small serial, sub-umbonal teeth in the Pteriid genus *Pteroperna*. There may be more affinity between the Pteriidae and the Taxodonta than is usually supposed.

V. SOME CRETACEOUS AND TERTIARY GENERA.

Parallelodon and *Beushausenia* became extinct at the end of the Jurassic, *Grammatodon* at the end of the Cretaceous.

Nevertheless, there arose in another stock, namely that of *Barbatia*, a development of the same elongate tendency in the teeth, by means of which the dentition came to resemble that of *Parallelodon*.

In the Eocene we find *Arca adversidentata* Deshayes,[2] having the unmistakable outward appearance and shape of *Barbatia*, yet the elongate posterior teeth of *Grammatodon*. On closer examination, however, the resemblance breaks down, and it is evident that the dentition is only secondary or "mimetic"; in other words, an instance of parallel development in a different stock. With this species as type (Fig. 14) a new genus *Pseudogrammatodon* is here suggested. It is still represented at the present day by a solitary species, the little *Arca dalli* of Japanese waters.

Another offshoot from the *Barbatia* stock was one in which both the posterior and anterior teeth grew long, almost threadlike, sinuous, and extremely irregular, while the unmistakable shell features of *Barbatia* remained unaltered. This genus was named *Cucullaria* by Deshayes, the genotype being *Arca heterodonta* Deshayes (Fig. 13) from the Eocene of the Paris basin.[3] A number

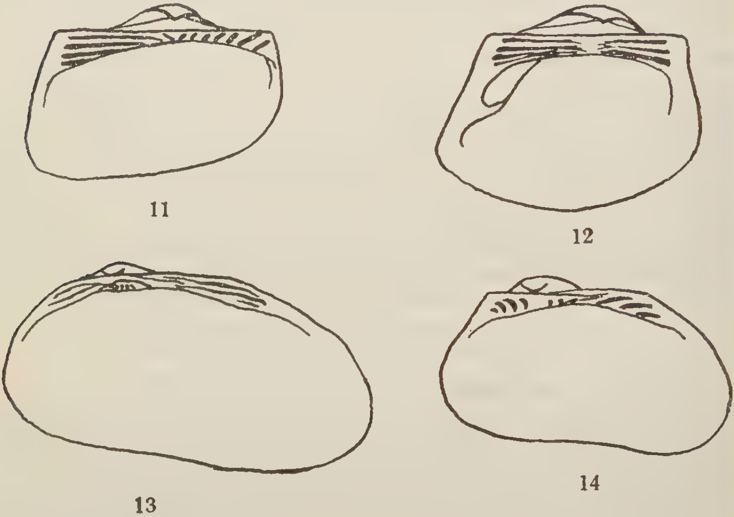
[1] 1924, *Grundzüge der Pal.*, ed. 6, p. 418.

[2] 1860, *Descr. foss. déc. dans le bassin de Paris*, vol. i, atlas, pl. lxviii, fig. 8.

[3] 1860, loc. cit., vol. i, p. 906, and atlas, pl. lxvii, figs. 22–4.

of species referable to *Cucullaria* have been figured from the Cretaceous of North America by Whitfield [1] under the generic name *Nemodon* Conrad. The dentition seems to have been too eccentric to be of biological advantage, and the genus did not outlast the Lower Tertiary.

Nemodon was not in the first place adequately described by Conrad,[2] but he stated that it was confined to the Cretaceous. It is classed by Meek tentatively as a sub-genus of *Parallelodon*[3] and Stoliczka also says, "I have some doubt whether it will prove to be sufficiently distinct from *Macrodon* (*Parallelodon*), with which the form of the shell entirely agrees." [4]



Figs. 11–14.—Hinges of *Grammatodon* (Fig. 11, left valve), *Cucullaea* (Fig. 12, left valve), *Cucullaria* (Fig. 13, right valve), and *Pseudogrammatodon* (*Arca adversidentata* Deshayes) (Fig. 14, right valve). Figs. 13 and 14 are drawn from Deshayes' original figures of the genotypes.

The exact nature of the characters remained for a long time in doubt, except for the fact of its having longitudinal anterior, as well as posterior, teeth. Recently, however, several species from the Upper Cretaceous of North America have been adequately figured, and all uncertainties are now dispelled—especially by those

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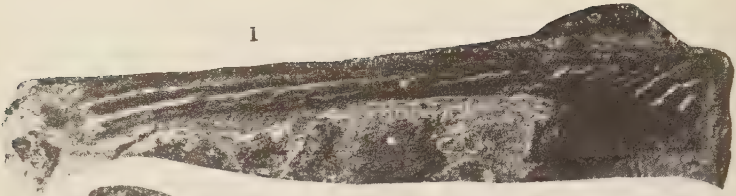
[1] 1885, *Brach. and Lamell. of the Raritan Clays and Greensand Marls of New Jersey*, pl. xii, figs. 1, 2, 5 (non figs. 3, and 4, probably true Nemodons).

[2] 1870, *Amer. Journ. Conch.*, vol. v, p. 97; and 1873, Appendix to Kerr's *Geol. Rept. N. Carolina*, p. 3.

[3] 1876, loc. cit., p. 83.

[4] 1871, loc. cit., p. 336.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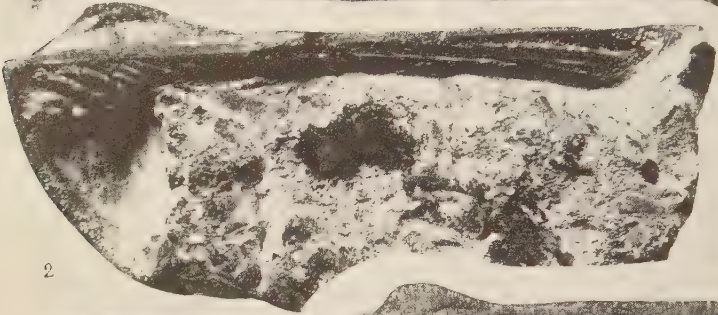
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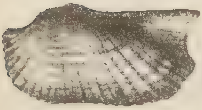
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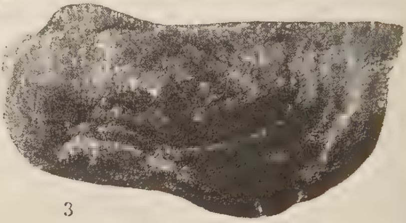
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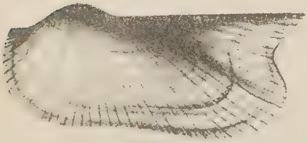
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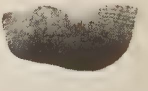
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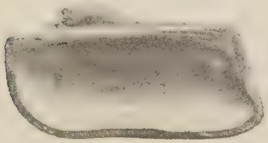
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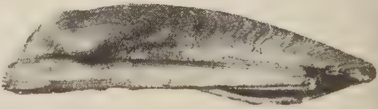
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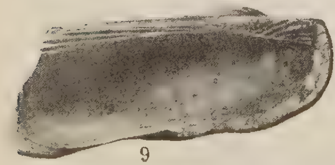
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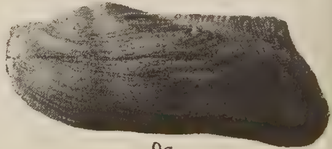
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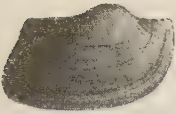
Parallelodon and Beushausenia.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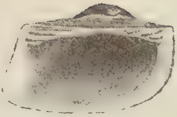
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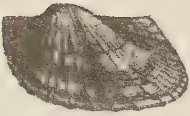
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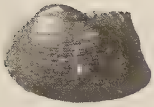
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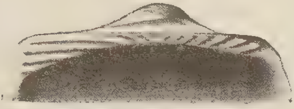
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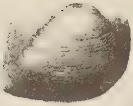
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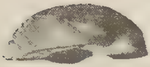
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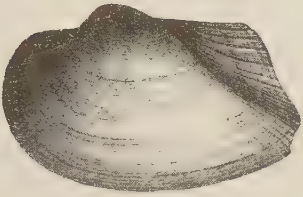
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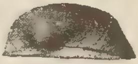
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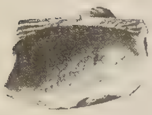
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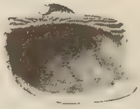
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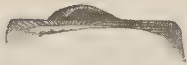
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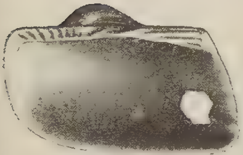
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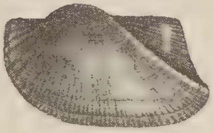
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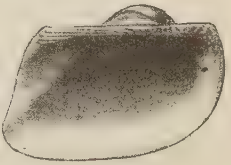
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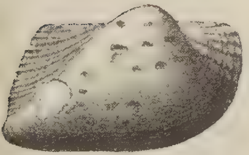
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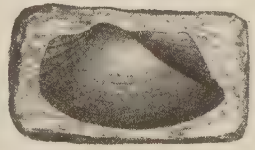
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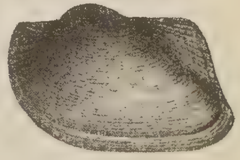
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GRAMMATODON.

in the extraordinarily well-preserved fauna of the Ripley Formation of Coon Creek, Tennessee, published by B. Wade.[1] *Nemodon simillima* Whiteaves, an elongate species with *Nemodon* dentition, from the Cretaceous of Maud Island near Vancouver, bears a sufficiently close resemblance to *Beushausenia* for J. F. Whiteaves to have at first identified it specifically with *Parallelodon* (*Beushausenia*) *fischeri* (d'Orb.) from the Oxfordian of the Ural Mountains.[2] These species can scarcely have any relation to *Cucullaea*, although by definition *Cucullaea* has both the anterior and posterior teeth elongate. It seems more probable that *Nemodon* arose as a modification of *Beushausenia* by the elongation of the anterior teeth ; that it was in the nature of an " expiring effort " before final extinction. This suggestion receives support from the fact that no raised plate for the attachment of the posterior adductor muscle, an essential character of *Cucullaea*, has been recorded in any species of *Nemodon*.

Nevertheless, since the teeth are different from those of *Parallelodon* and its sub-genera, it seems advisable to regard *Nemodon* as a separate genus.

EXPLANATION OF PLATES XIV–XVI.

Plate XIV.

Fig.

1–4. *Parallelodon rugosum* (Buckman), the type species, showing hinge and anterior adductor attachment of left and right valves and exterior of left valve at younger stages of growth. Morris and Lycetts specimens, Mus. Pract. Geol., from the Great Oolite, Minchinhampton, Glos. Reg. Nos. 9,333, 9,332, 9,330, 9,331.

5. *Parallelodon rudis* (Sow.), Great Oolite, Minchinhampton, Glos. Mus. Pract. Geol. No. 4,9026.

6. *Parallelodon bipartitum* (Roemer), Lower Calcareous Grit of the Ardennes and the Coral Rag of Verdun. After Buvignier.

7. *Parallelodon mosensis* (Buvignier). Original figure of the holotype, Kimeridge Clay, Mauvage, Meuse. After Buvignier.

8. *Parallelodon* (*Beushausenia*) *buckmani* (Richardson). Interior of right valve. Lower Lias, Adderbury. Beesley Coll., Oxford Univ. Mus.

9, 9*a*, 10. *Parallelodon* (*Beushausenia*) *keyserlingii* (d'Orb.). Oxfordian of Central Russia. After Borissjack.

Plate XV.

1. *Parallelodon* (*Grammatodon*) *inaequivalvis* (Goldfuss). Lias of Wurtemberg. Original figure of holotype, after Goldfuss.

2, 3, 4. *Parallelodon* (*Grammatodon*) *concinnum* (Phillips). Oxford Clay of England and the Swiss Jura. Fig. 4, the holotype in the Yorkshire Museum, York. After de Loriol.

5. *Parallelodon* (*Grammatodon*) *alsaticum* (Roeder). Upper Oxfordian of Pfirt and the Swiss Jura. After de Loriol.

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[1] 1926, U.S. Geol. Survey, Professional Papers, No. 137, pp. 42–3, plates viii and ix.

[2] 1884, " Foss. of the Cretaceous Rocks of Vancouver and adj. Islands in the Straits of Georgia," *Geol. Surv. Canada, Mesozoic Foss.*, pp. 234, 293, pl. xxxi, fig. 5.

6. *Parallelodon* (*Grammatodon*) *montanayensis* (de Loriol). Oxfordian of the Swiss Jura, and also found in the Oxford Clay in the Kent coal borings. Holotype, after de Loriol.
7. *Parallelodon* (*Grammatodon*) *schourovskii* (Rouillier). Volgian of Central Russia. After Borissjack.
8. *Parallelodon* (*Grammatodon*) *pictum* (Milasch). Oxfordian to Sequanian of Russia. After Borissjack.

Plate XVI.

1. *Navicula hiantula* (Deshayes). Tertiary of Central Europe. Note outward splaying of teeth. After Goldfuss.
2. *Navicula dupiniana* (d'Orbigny). Lower Greensand. One of the earliest known forms of true *Navicula*. After Woods.
3. *Navicula* (*Eonavicula*) *carteroni* (d'Orb.). Lower Greensand. A transitionary form between *Eonavicula* and *Navicula*. After Woods.
4. *Navicula* (*Eonavicula*) *trichordis* (de Loriol). Upper Oxfordian of Pfirt and the Swiss Jura. After de Loriol.
5. *Navicula* (*Eonavicula*) *minuta* (Sow.). Great Oolite of Minchinhampton, Glos., Mus. Pract. Geol. No. 9196.

6, 7. *Navicula* (*Eonavicula*) *eudesii* (Mor. & Lyc.). Great Oolite and Forest Marble. Fig. 6, the holotype, from the Great Oolite of Minchinhampton. Mus. Pract. Geol. Nos. 10865, 49022.

8. *Navicula* (*Eonavicula*) *quadrisulcata* (Sow.). Corallian (Rauracian), Settrington Grange, Yorks. Mus. Pract. Geol.

(*To be continued.*)

The Geology of the Farsan Islands, Gizan and Kamaran Island, Red Sea.

Part 1.—General Geology.

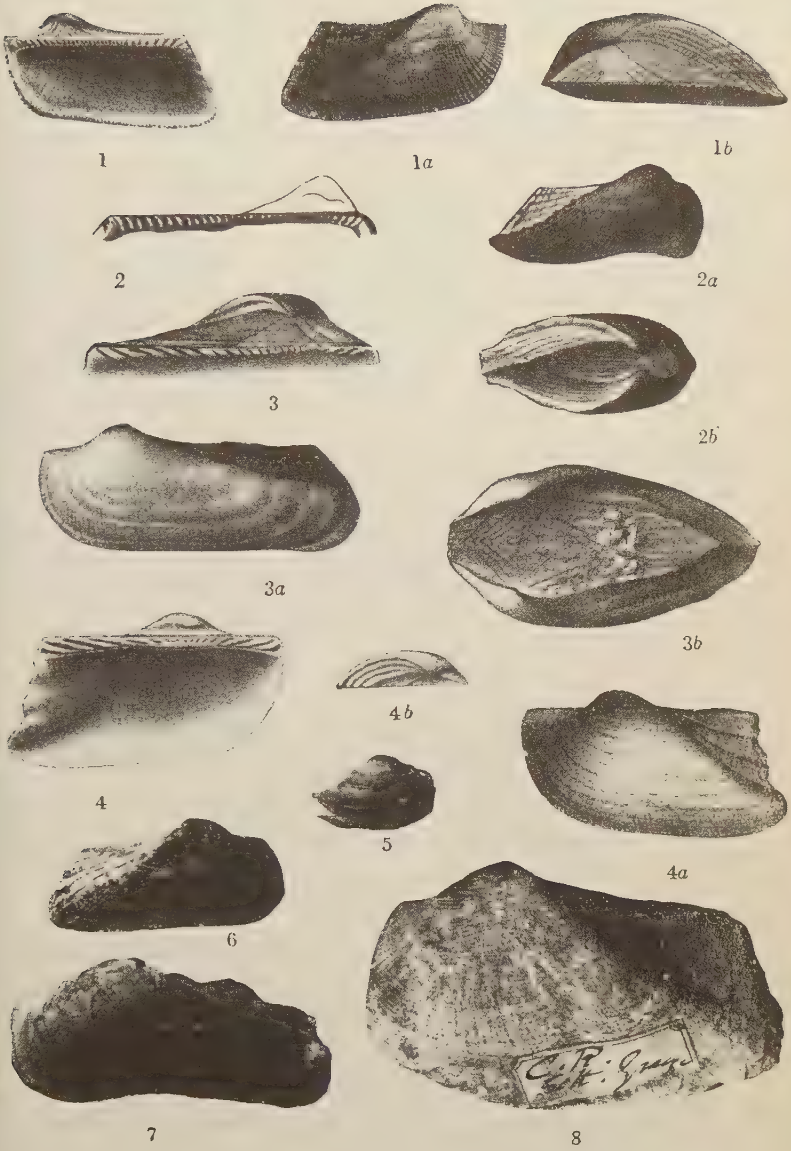
By W. A. Macfadyen, M.C., Ph.D., F.G.S.

Introduction.

The Farsan Islands form a group in the southern part of the Red Sea, about 17° N. Lat., 42° E. Long., and lie some 40 km. off the Asir Coast of south-west Arabia. The two main islands are Farsan Kebir (whose north-western arm is known as Seïr), and Segíd, which nestle together with a length of 60 km. and breadth of roughly 25 km. There are five smaller islands varying in length from 5 to 13 km., and a host of minor islets and rocks. The islands are in general of rather low elevation, not rising to more than 10 to 20 metres above sea-level. Local hills occur up to 75 metres, and are mostly due to faulting, occasionally to folding.

Prior to the war, the Farsan Islands were under Turkish jurisdiction, and had a Turkish garrison; but in 1915 they were seized by the Idrissi (the rulers of Asir), who still retain them.

Three islands, Farsan Kebir, Segíd, and Gumah, are now permanently inhabited, and there are traces of abandoned stone huts on two others, Disan and Zifaf. There are some fifteen villages, and in addition to pearl fishing, agriculture is practised in scattered localities, but crops are dependent on the rare rain showers. There are considerable date groves round some of the villages. Water



NAVICULA AND EONAVICULA.

[*To face p.* 310.

which is only slightly brackish is plentiful on the main islands, and a large number of wells have been dug to the level of the water table (about sea-level) through the limestone. They vary in depth up to 24 metres.

Gizan is one of the chief towns of the Asir coast, over against the Farsan Islands. It is important geologically since there apparently is the only section of lower strata exposed on this part of the mainland coast.

Kamaran Island lies 150 km. to the south, close to the Yemen coast, and is some 22 km. long. It is under British administration, and is the site of an important quarantine station for the pilgrim traffic from the East.

The maps given in Text-figures 1 and 2 are taken from the British Admiralty Chart, " Red Sea—Sheet 4," with many alterations in the names. These names, together with the others used in this paper, are those at present in use by the natives, and were written down phonetically ; they often differ entirely from those given on the Admiralty charts.

The fieldwork and collecting were done by the writer between November, 1926, and February, 1927, when an examination of the islands was made for the Red Sea Petroleum Company. Through the courtesy of the Directors of this Company the fossil collections were divided between the British Museum (Natural History) and the Sedgwick Museum, Cambridge. The writer is further indebted to the Directors for permission to publish this account.

I. THE FARSAN ISLANDS.

These are fringed with a growing coral reef, with some beaches of pure calcareous sands. No grain of quartz sand or igneous mineral was found in the islands, either in the modern beach sands or in the older strata ; this is due evidently to the position of the Islands, now, as in the past, a marine bank some distance from land, and in a sea bounded by arid coasts whence detritus is seldom washed.

Stratigraphy.

The succession observed may be summarized as follows :—

(*d*) *Raised Beaches*, with undercut cliffs,[1] are found at many places on the islands, but appear occasionally to be missing. There are generally two ; their heights above the present-day high-water mark were measured at Ras Hassis (Farsan Kebir), and found to be 1·3 and 2·7 metres respectively. Isolated heaps of unconsolidated (but packed) shells, often with the original colour preserved, are sometimes found above the Raised Beaches, and perhaps constitute evidence of a higher Raised Beach at 6 to 8 metres above present-day high-water mark. They do not appear to be due to human agency.

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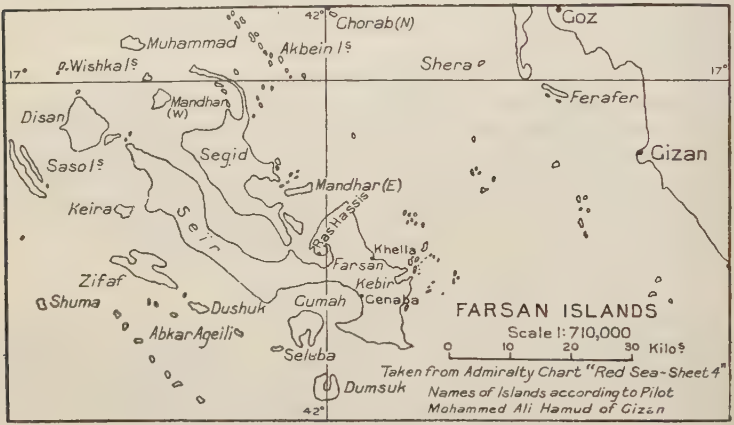
[1] W. A. Macfadyen, 1930, " The Undercutting of Coral Reef Limestone on the Coasts of some Islands in the Red Sea," *Geographical Journal*, vol. lxxv, pp. 27–34.

(*c*) *Reef Limestone.*—By far the greater portion of the islands consists of this formation. It is a well-consolidated, very fossiliferous limestone, mainly made up of coral reef, with many lamellibranchs and gastropods (often as casts) and echinoids. It is light in colour, but weathers brown. In places it passes gradually down into the Marly Limestone Series below (as at Zifaf Island and Seïr); in others it rests unconformably upon the Marly Limestone Series (as at " South of Mharak Village in Farsan Kebir ", and elsewhere, the junction being marked by a limestone pebble bed), or on the Fish-Diatom Marls (as at places at Ras Hassis). It is extensively faulted, and although it is usually inclined at a low angle, dips up to 32° are recorded. The faulting makes it difficult to estimate its thickness, and in exposed sections (usually fault-scarps) the maximum thickness measured was some 15 metres, but the actual thickness is probably greater. It forms the highest points of the islands at an altitude of 75 metres.

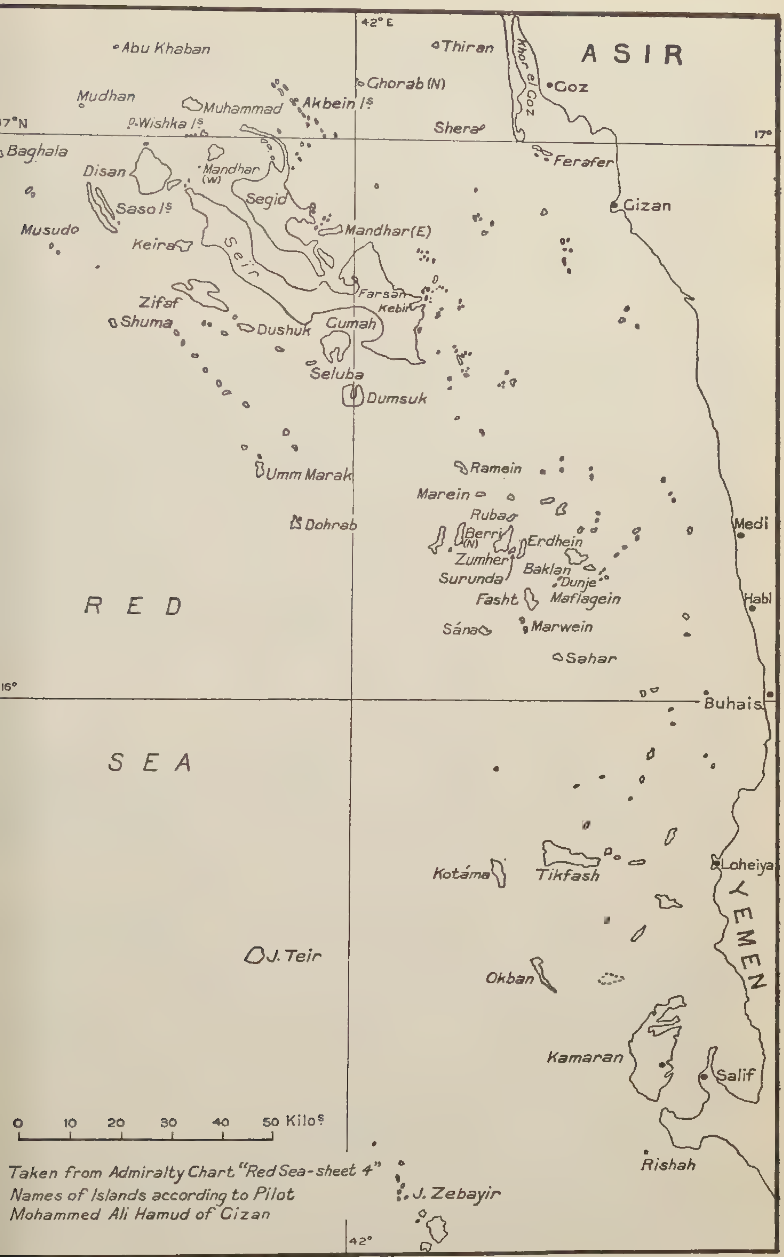


Taken from Admiralty Chart "Red Sea-Sheet 4"
Names of Islands according to Pilot Mohammed Ali Hamud of Gizan

FIG. 1.—Map of the Farsan Is. and Gizan.

(*b*) *Marly Limestone Series.*—This series is seen only at a few isolated outcrops on the Islands, always beneath the Reef Limestone. Towards the top it is usually white (the *White Limestone*); the lower part consists of yellow, pink and green marly limestones, with rare bands of clay. The greatest thickness observed was about 50 metres. Highly fossiliferous bands occur, but these are often separated by rather barren layers. At Gebel Uzbah, Seir Peninsula, this series contains *Operculina complanata* (Defrance) and var. *granulosa* Leymerie.

(*a*) *Fish-Diatom Marls.*—These curious beds are seen in two places



Taken from Admiralty Chart "Red Sea-sheet 4"
Names of Islands according to Pilot
Mohammed Ali Hamud of Gizan

Fig. 2.—Map of the Farsan Is., Gizan and Kamaran Id.

only, at Ras Hassis (Farsan Kebir), and at Mandhar Island East. They are white or pale green, finely laminated, and contain abundant fish remains and diatoms. Dr. E. I. White has kindly examined some of the fish remains, and reports that they belong to the family Clupeidæ, but are not generically identifiable. At Ras Hassis there is only 10 metres of the Marly Limestone Series above the Marls, and it is probable that they are merely a lenticular intercalation in the Marly Limestone Series. A thickness of 20 metres was measured, but since their base is nowhere exposed their total thickness is unknown.

Tectonics.

The Farsan Islands owe their origin to the uplift of a shallow marine bank, the long axis of which is parallel to the Red Sea trend. Normal faulting (usually parallel to the strike) is frequent. Open fissures are common in the surface limestone throughout the Islands; they are parallel to the structural trends, and are up to some 3 metres wide and 8 metres deep. They have evidently been caused by the stiff Reef Limestone yielding more easily by fracture than by folding; it must have been actually on the surface during the relatively recent tectonic movements.

Flexures are not common, although there are a few minor folds in the group, of which that composing Zifaf Island is perhaps the largest. A boring on Zifaf Island passed through 120 metres of coral limestone, marly limestone, and marls, which overlay rock salt to a depth of 470 metres. The Fish-Diatom Marls were not recognized.

II. GIZAN.

The town is built at the base of a small series of tumbled hills which rise to some 60 metres above sea-level, and extend along the coast for 2 to 3 km. Inland a low-lying plain stretches eastward to the base of high hills many miles away, the topography shown on the 1 : 250,000 map being largely imaginary.

Stratigraphy.

Owing to the very broken nature of the hills, the very high angles at which the strata often dip, and the obscuring of many critical boundaries between different strata by downwash, the following succession had to be pieced together from isolated observations:—

(*e*) Thin residual soil and alluvial hill-wash, with recent gastropods[1] sometimes abundant.

(*d*) *Reef Limestone Series*, thin and in places missing, with the large oyster, *Ostrea turbinata* Lamarck.

(*c*) *Marly Limestone Series.*—The White Limestone facies at the top is not developed and the whole series is thin (5 metres); it includes sandy limestones (sometimes with chert pebbles) and calcareous quartz-sands and sandstones.

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[1] Major M. Connolly has kindly identified these as *Zootecus insularis* (Ehrenberg) and *Euryptixis labiosus* (Müller).

(*b*) *Gypsum Series.*—(?) 50 metres. Banded gypsum with subsidiary shales and thin limestone bands in the lower part. No fossils were collected. This may probably be correlated lithologically with the Miocene Gypsum-Salt-Shale Series of Egypt. Rock salt is exposed in a salt quarry close to Gizan town, on the north of the hills. Its position in the succession is not clear, but it is probably connected with the Gypsum Series.

(*a*) *Sandstone Series.*—Brown and red quartz-sands and sandstones, often with pebbles; unfossiliferous. This is not dissimilar to the Nubian Series in Egypt and Makella, which is mainly Cretaceous.

Tectonics.

The tectonics of the Gizan Hills are obscure and insufficient time was available for their study. Faulting is common; dips approaching 90° were observed in some of the gypsum and shale-and-limestone bands, and a remarkable cliff in the coast-section towards the south of the hills showed highly contorted folding of gypsum and shales. On the southern margin of the hills, the strata dip sharply beneath the flat plain. In this area recent folding and faulting usually produce well-marked surface features. Since the Gizan hills are the only topographical feature in the neighbourhood, the stresses were probably developed very locally, and were perhaps caused by intrusive salt.

III. KAMARAN ISLAND.

This island is in general low, and flat-lying almost throughout, not rising on an average to more than some 10 metres. The surface, where not covered by recent residual soil, sand or swamp, is practically entirely composed of the Reef Limestone formation. Much the best section to be found on the island is conveniently situated at Milton Point, at the mouth of the small inner harbour of Kamaran and is as follows:—

(*b*) *Reef Limestone.*—6 metres. The same very fossiliferous coral reef formation as seen in the Farsan Islands, but here more marly. The large species, *Ostrea turbinata*, is present.

(*a*) *Marly Limestone Series.*—4 metres (seen). Soft yellow-green marls, with fairly abundant worn foraminifera, mainly of the two common species *Rotalia beccarii* Linné and *Polystomella crispa* Linné. A single worn specimen of *Amphistegina lessonii* d'Orbigny was also found. Ostracods are frequent.

IV. SUMMARY OF STRATIGRAPHY.

Comparing the Reef Limestone and Marly Limestone Series at Farsan, Gizan and Kamaran, it is seen that at Farsan there is a purely marine shallow-water facies. At Gizan there is a more or less littoral facies with the incoming of quartz and igneous minerals in the sand, while at Kamaran there is a shallow-water marine facies, more marly than at Farsan.

(*To be continued.*)

Notes on the Cambrian Fauna of Persia.

By W. B. R. King.

[*Published by kind permission of the Chairman of the Anglo-Persian Oil Company, Ltd.*]

(PLATE XVII.)

THE material which is described in this note was collected by members of the Geological Staff of the Anglo-Persian Oil Company, Ltd.

The first Cambrian fossils found in Persia were some trilobites discovered by Dr. G. M. Lees at Al Buza, in March, 1925, in the course of a reconnaissance with Professor Dr. H. de Böckh, Mr. S. Lister James, and Mr. F. D. S. Richardson. A preliminary account of these is given by de Böckh, Lees, and Richardson (12, p. 78),[1] but a complete description has not yet been published.

The specimens now under consideration were discovered by Messrs. Richardson and W. A. Franklin in the season 1925–6 (Kuh-i-Namak and Ras Bustaneh), by Dr. Lees in 1926 (Narghun), and by Messrs. R. C. Jennings and K. Washington Gray in the season 1926–7 (Darreh Duzdan, Irij, Kuh-i-Dinar, and Kuhbanan). The specimens from Kuh-i-Namak were found in blocks of rock washed down from a salt-plug, and may therefore represent more than one horizon, and those from Darreh Duzdan occurred in an isolated boulder; all the remaining specimens were obtained in situ, although under very disturbed structural conditions. A full account of the Cambrian of Persia, including the observations of the above geologists, is given by de Böckh, Lees, and Richardson (12, pp. 69–85, 124, 126, 127, 128, 136), where reference is made to all the localities mentioned above.

The commonest fossils from each locality are trilobites; most localities, however, also yield atrematous brachiopods, while those which are presumed to be in the higher beds of the Cambrian generally yield protrematous brachiopods. Amongst the material for the salt-plug of Kuh-i-Namak are slabs of limestone with remains of ossicles and plates of what is probably an early form of cystid, using that name in its widest sense. They are probably of Upper Cambrian age, as they are associated with brachiopods of Billingsella type.

REDLICHIA CHINENSIS Walcott. (Pl. XVII, Figs. 1, 1*a*, 1*b*, 1*c*.)

Redlichia has been found in two widely separated localities in Persia, at Kuhbanan and Kuh-i-Dinar. The rock in which the specimens are preserved is a hard platy or finely crystalline limestone; when broken the majority of the rock specimens show little or no structure and nearly all the fossils are on the weathered surfaces and are extremely difficult to develop out of the matrix. One specimen, however, from Kuh-i-Dinar contained many beautiful fossils, which were extracted from the rock mass, and these show all the details and surface marking of the cranidium.

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[1] See list of references, p. 326.

The form agrees closely with the figures and description of Walcott and Mansuy for *R. chinensis*, although there are a few differences which will be noted below.

The shape of the glabella shows that the Persian fossils belong to the *R. chinensis* group rather than to the *R. noetlingi* forms from India; this is also borne out by the angle which the genal spine makes with the posterior parts of the free cheek. In the Persian specimens and *R. chinensis* this angle is 55°, while in *R. noetlingi* it is slightly larger and in the other species from China figured by Walcott this angle is considerably larger.

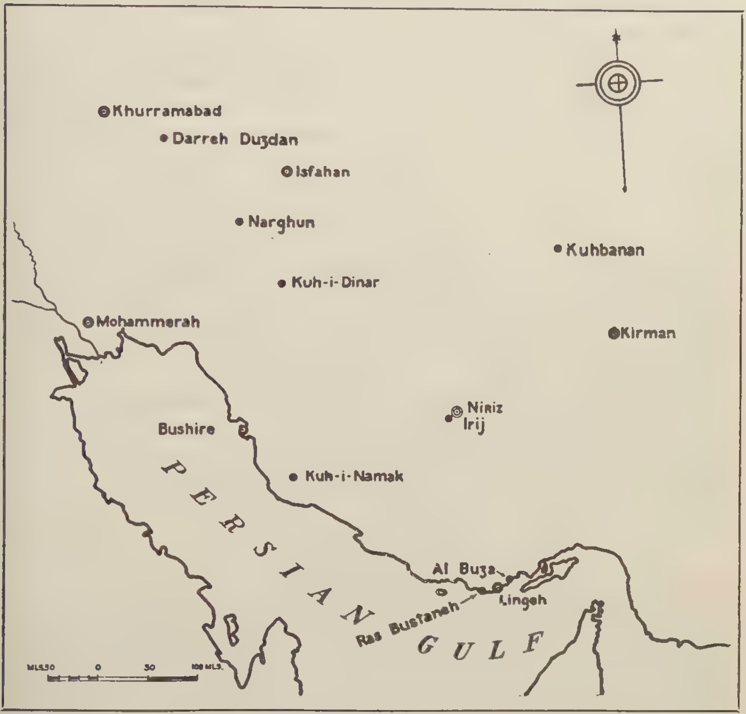


FIG. 1.—Map of the Persian Gulf area.

In noting the difference between the form from Persia and *R. chinensis*, it must be stated that they are all of a minor nature, and only visible on the beautifully preserved specimens obtained from the unweathered rock of a single block.

The whole glabella, except in the furrows, is covered with short, irregular, roughenings, which in the anterior lobe tend to be arranged parallel to the anterior margin of the glabella, while on the posterior portions they appear more or less as a rash on the even surface of the shell.

The anterior ridge and the wing-like parts of the pre-glabella field are ornamented with narrow wavy ridges similar to those noted in *R. chinensis* by Mansuy; he, however, notes that the hollow between the anterior ridge and the pre-glabella field is ornamented by a line of very small spine-like tubercules, while in the Persian specimens this line is marked by a series of small, but well-defined pits (Fig. 1*b*).

Very few thoracic segments appear to have been found, but such as there are agree closely with those from China figured by Walcott as belonging to this species.

The differences noted above do not appear to be sufficient to justify the creation of even a varietal name for the Persian forms.

FORMS REFERABLE TO THE GENUS ANOMOCARE.

Taking *Anomocare* as interpreted by Walcott, it would appear that the majority of the smaller forms in this collection are referable to this genus.

The specimens fall into several distinct groups, most of which are nearly related to forms already described from other parts of Asia, although at least two species appear to be new.

The forms can be identified as belonging to the following species :—

Anomocare megalurus (Dames).
,, *latelimbatum* Dames.
,, *subquadratum* (Dames).
,, cf. *ephori* Walcott.
,, *dikellocephaloides* sp. nov.
,, *persicum* sp. nov.

A. megalurus is figured here (Figs. 4 and 4*a*) because several excellently preserved cranidia have been obtained from a small block of limestone JG/ZE/1461 from Kuhbanan, while several other good specimens occur on blocks with *Redlichia* from the same locality. The chief point of interest of these specimens is that they show the character of the surface ornamentation of the shell. The whole cranidium is covered with a fine granulation, and the glabella furrows are only faintly marked.

A. latelimbatum is a form which occurs in extraordinary abundance in certain pieces of limestone from Kuh-i-Namak, in fact, the rock is mainly composed of detached cranidia and pygidia, which clearly belong to one species. None of the specimens are particularly well preserved, and they do not exhibit the surface ornamentation, but the general details are clearly seen as is also the characteristic snout-like form of the frontal rim well shown in Dames' figures (1, pl. ii, fig. 9), while the pygidia have the entire margin and well formed axis figured by Walcott (7, pl. xviii, fig. 2).

There can be little doubt that the form is nearly related to, if not absolutely identical with, Dames' species from China.

A. subquadratum is referred to Dames' species largely on the square outline of the glabella and general dimensions. Most of the specimens are from a buff coloured shaly silt from Ras Bustaneh, and have lost their calcareous shell, but one specimen from Kuh-i-Namak (Figs. 5 and 5*a*) is from a thin bedded limestone and allows a more close comparison with Dames' (1) and Walcott's (7) figures for the species, with which it agrees very closely.

Anomocare cf. *ephori* Walcott.—A piece of limestone from the Bakhtiari Road, collected by Dr. Lees (B.M. No. In 27691), contains portions of a cranidium which has many features in common with *A. ephori* of Walcott from the Middle Cambrian of China (7, p. 190, pl. xviii, fig. 5). It is associated here with *Billingsella* and *Chuangia*.

A. dikellocephaloides is from Darreh Duzdan, and *A. persicum* is from Kuh-i-Namak; these being new are described in detail below.

It is interesting to find that out of the great number of species of *Anomocare* and *Anomocarella* described from China by Walcott, nearly all the forms in this collection can be compared with Dames' species.

Anomocare dikellocephaloides sp. nov. (Figs. 2, 2*a*, and 2*b*).—This species rests on the specimens from a small block of limestone numbered JG/ZE/821 from Darreh Duzdan. It was at first thought to be a *Dikellocephalus* (12, pp. 124, 126), but further development from the matrix has revealed that it belongs to *Anomocare*. Only the anterior part of the cranidium and two pygidia are preserved, but they have an extremely characteristic form.

The glabella is nearly parallel-sided and only slightly rounded on the anterior margin; traces of the two anterior glabella furrows are preserved. The width of the fixed cheeks at the palpebral lobe is about equal to that of the glabella, and the eye is on a level with the anterior lobe of the glabella, whilst the faint eye-line runs from the anterior end of the palpebral lobe to the glabella at a point where the rounding of the anterior margin begins. In front of the glabella is a wide pre-glabella area which is separated from an extremely wide flat border by a slight groove. The whole cranidium is extremely flat, neither the glabella nor the border rising much above its general surface level. The surface of the test appears to be smooth.

The two pygidia associated with this cranidium show a normal segmented axis and faint segmentation of the pleural portion. The margin, however, appears to be broad, flat, and ornamented with anastomosing wavy striae. It is prolonged posteriorly to form a forked end to the pygidium similar to that figured by Walcott for *Anomocare lisani* (7, pl. xviii, figs. 4*d* and *e*).

The form here described would appear to have much in common with *A. lisani*, but the very broad flat border to the cranidium precludes its inclusion in that species.

Associated with this form are some small specimens referred to *Anomocare* cf. *megalurus* (Dames) and a brachiopod which is probably *Billingsella tonkiniana* (see p. 323).

This assemblage of forms would appear to indicate a high Middle Cambrian horizon for this specimen.

Anomocare persicum sp. nov. (Pl. XVII, Figs. 3 and 3*a*.)

This species is based on a single cephalon from Kuh-i-Namak found in a limestone block with *Billingsella tonkiniana* and Anomocare sp.

The glabella is subquadrate in form, being slightly longer than wide ; the glabella furrows are only very faintly seen ; the base of the palpebral lobe is opposite the centre of the glabella.

The width of the pre-glabella field is one-third the length of the glabella and the anterior rim about a quarter the length of the glabella ; the fixed cheeks (apart from palpebral lobe) are continuous with and same width as the pre-glabella area. The surface of the shell is smooth and the general relief of the cephalon slight.

In many particulars it resembles *A. subquadratum* (Dames), but differs from that species in the width of the pre-glabella field and the size of the anterior rim.

The very faint glabella furrows might place the form in Anomocarella, but from its apparent connection with *Anomocare subquadratum* it would appear to be advisable to place it in the same genus as that form.

FORMS REFERRED TENTATIVELY TO THE GENUS COOSIA.

Cf. *Coosia asiatica* Mansuy. (Text-fig. 2.)

The specimens provisionally referred to this species occur in a fissile maroon-coloured micaceous sandy silt and show little except the general outline of the cephalon and pygidium.

The cephalon is almost flat in its present state of preservation, and shows a tapering conical glabella and wide flat frontal rim, it is similar in form to Mansuy's figure (9, pl. vii, fig. 6*e*).

The pygidium has a tapering axis of eight segments and broad margin with parallel striae similar to Fig 6*g* of the above reference.

The only doubt about referring to this genus and species is that the anterior margin of the frontal rim appears to be slightly protruding, and this does not conform with the almost exact semicircle typical of the species.

FORMS REFERRED TO THE GENUS CHUANGIA. (Pl. XVII, Figs. 6 and 7.)

Several isolated cranidia which appear to belong to this genus have been obtained from Kuh-i-Namak, but only one is well preserved. Some specimens of a cream-coloured limestone yield some cranidia and pygidia which also appear to belong to this genus but possibly to another species.

The Persian specimens (Figs. 7 and 7*a*) agree well with Walcott's species *Chuangia nais* (7, pl. xvi, fig. 1) and have the characteristic slight swelling of the glabella at its anterior margin but the one well-preserved specimen shows that the whole glabella and fixed cheeks are covered with small but definite punctae except on the parts corresponding to the position of the anterior glabella furrows.

The free cheeks which may belong to this species are characterized by a short stout genal spine.

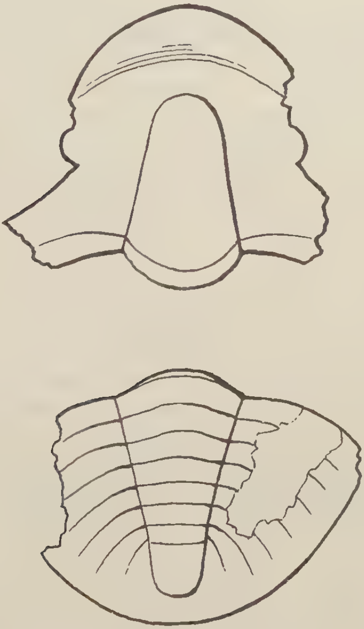


FIG. 2.—Cf. *Coosia asiatica* Mansuy. × 2.

Certain specimens from the cream-coloured limestone of Kuh-i-Namak clearly belong to this genus and are in many respects similar to the form referred to *C. nais*, although they are not nearly so well preserved. The pygidia associated with these possess a marked narrow axis of about ten segments and a broad smooth entire margin between which and the axis are about seven rather faint pleural rings.

Mansuy (8, pl. ii, fig. 14), however, figures pygidia found associated with *C. nais*, which have long spines on the anterior angles of the pygidium. One specimen amongst the numerous pygidia of the type associated with the Persian specimens has been obtained (Fig. 7*b*) in which there are the remains of well developed spines on the anterior angles of the pygidium very similar to Mansuy's figure. It is probable that in the Persian material there are two species of *Chuangia* with very similar cranidia but with distinctive pygidia. It would, however, be advisable to await more definite material before creating any new species.

This species, *C. nais*, is found in upper Cambrian strata in China and Indo-China. It would appear, therefore, that the Persian specimens are probably from a high Middle or Upper Cambrian horizon.

Mr. Withers called my attention to the specimens collected by Dr. G. M. Lees from Narghun on the Bakhtiari Road in 1926, and presented by him to the British Museum. They contain a beautiful cranidium of a small specimen referable to *C. nais*, and a hypostome associated with this species. The cranidium (Fig. 6 and 6*a*) appears to have all the characters of the genus and to be closely allied to the species *C. nais*, it differs from the specimen from Kuh-i-Namak in having a less punctate shell, but this may in part be due to the smaller size of the specimen. The hypostome (Fig. 6*b*) is fairly square in outline with not very pronounced wings and has a raised central spherical portion.

FORMS REFERRED TO THE GENUS BILLINGSELLA. (Pl. XVII, Fig. 8, and Text-fig. 3.)

Certain blocks of slightly dolomitized limestone from Kuh-i-Namak are crowded with fossils which have preserved their calcareous shells and thus show their external shape and markings. When the rock is treated with weak acid the shell is removed and a fragile cast of the internal structures is left, which can be hardened by impregnation with wax. In this way considerable detail of structure has been made out.

The structures revealed show clearly that the forms belong to the genus Billingsella, although the specimens are of exceptionally large size for the genus. It does not come very near to any described by Walcott (6), but *B. tonkiniana* of Mansuy (8 and 9) has many points in common with it, both in the general form of the shell and also in the internal structures. Since the Persian specimens are not deformed in any way and show all the internal structures, it may not be out of place to give a description of them.

Billingsella aff. *tonkiniana* Mansuy.

External Characters.—Both valves gently convex.

Width at hinge line, 2·2 cm.
Length hinge to border, 1·5 cm.
Height near umbo (each valve), 0·4 cm.

General outline semi-circular—hinge line straight greatest width of shell which is slightly alate in form. Surface ornamented with about thirty well defined radial ribs, each rib being divided by three or four faintly defined lines.

Internal Characters : Ventral valve.—The well defined area is bounded by margins which meet at the umbo in an angle of 140°. The angle of the exterior of the valve to the area is only 25°.

The inner surface of the area is marked by striae parallel to the hinge line.

The delthyrium has an apical angle of 60°. It is covered by a slightly curved deltidium with faintly curved growth lines. There is a minute pedicle opening near the apex visible in some specimens.

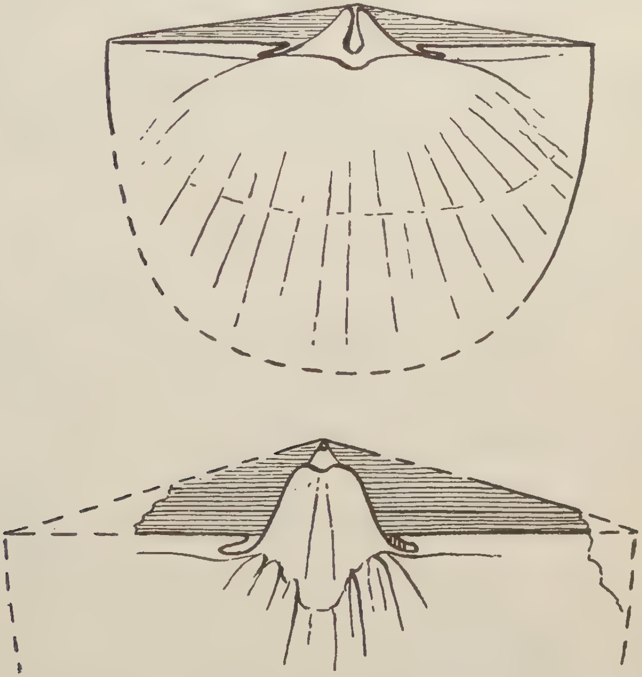


Fig. 3.—*Billingsella* aff. *tonkiniana* Mansuy. × 3.

The straight hinge line has a pair of short, strong teeth at the edge of the delthyrium. These show five or six marked vertical ribs on the side next the area. There is a well-developed pseudospondylium which restricts the size of the umbonal cavity and traces of muscle scars can be seen on the pseudospondylium. Those parts of the shell on either side of the pseudospondylium (which appear in the natural casts as raised shoulders) show on the inner surface of the shell radiating lines which are probably the markings of the vascular tissues.

Dorsal Valve.—The area makes nearly a right angle with the exterior part of the valve, its greatest height is about 0·2 cm. There is a well defined simple cardinal process; both dental sockets and crural plates are well defined but short. The inner surface of the dorsal valve appears to be smooth.

Obolus (*Westonia*), sp.

A slab of dark maroon-coloured calcareous silt from Kuh-i-Namak is crowded with an atrematous brachiopod between 5 and 7 mm. in diameter. The ventral valve is somewhat pear-shaped and the dorsal nearly circular. The surface ornamentation shows the

LOCALITIES.

Kuhbanan, N.W. of Kerman. Long. 56° 23 E. Lat. 31° 23 N.	Kuh-i-Dinar. Long. 51° 20 E. Lat. 31° 0 N.	Darreh Duzdan. Long. 49° 30 E. Lat. 33° 18 N.	Irij, S.W. of Niriz. Long. 54° 4 E. Lat. 29° 7 N	Kuh-i-Namak Dashti. Long. 51° 40 E. Lat. 28° 18 N.
Specimen number between JG/ZE/1446–1479	between JG/ZE/2953–3003	JG/ZE/821 only	JG/ZE/2071–2 only	no numbers.
Redlichia chinensis *Anomocare megalurus* Large *Obolus* (?) *Hyolitus* sp.	*Redlichia chinensis* *Anomocare megalurus*	*Anomocare dikellocephaloides* (sp. nov.) *A.* cf. *megalurus* *Billingsella* cf. *tonkiniana*	*Anomocare* sp.	*Anomocare latelimbatum* *A. subquadratum* *A. persicum* (sp. nov.) *Chuangia nais* *Ch.* sp. ? *Coosia asiatica* *Billingsella tonkiniana* *Obolus* (*Westonia* sp.
Ras Bustaneh, W. of Lingeh Long. 54° 42 E. Lat. 26° 36 N.	Narghun near Du Pulan Bakhtiari Road. Long. 50° 35 E. Lat. 32° 0 N.			
No numbers	Specimens in the British Museum Lees Collection.			
Anomocare subquadratum	*Anomocare* cf. *ephori.* *Chuangia nais* *Billingsella tonkiniana.*			

"ripple-embossed" lines characteristic of the Westonia subgenus of *Obolus* (6, p. 450). The details of the muscle scars cannot be made out but the general appearance is not unlike *Obolus* (*Westonia*) *euglyphus* (Walcott) (6, pl. xlviii, fig. 1) from the Middle Cambrian of Arizona.

PROBABLE AGE OF THE SPECIMENS.

In China *Redlichia chinensis*, according to Walcott, indicates a Lower Cambrian age, but apparently near the top of the Lower Cambrian; Mansuy (5) found *Redlichia* at three horizons in the Cambrian of Yunnan and concluded that the highest horizon is probably Middle Cambrian, although later (8) he relegated all the *Redlichia* beds to the Lower Cambrian.

It is to be noted that in China the *Redlichia* come from beds below those in which *Anomocare* and allied forms are common, while in Persia *Redlichia* occurs on the same slab of rock as species of *Anomocare*. This would suggest that in Persia at Kuhbanan and Kuh-i-Dinar the strata which yield *Redlichia* are either very high in the Lower Cambrian or perhaps low Middle Cambrian in age. When the fauna from the other localities is considered the list of genera and species is seen to be quite different. There is no sign of Lower Cambrian forms; various species of Anomocare are the commonest forms, while the genera *Chuangia* and *Coosia* among the Trilobites and the highly developed type of *Billingsella*, all point to an age somewhere near the base of the Upper Cambrian or at the summit of the Middle Cambrian.

The conclusion is, therefore, that in Persia there are two fossiliferous Cambrian horizons, one at or just below the base of the Middle Cambrian and the other at or just below the base of the Upper Cambrian.

RELATIONSHIP OF THE FAUNAS TO THOSE OF OTHER AREAS.

Naturally, the first area with which comparison is to be made is northern India, both the eastern Salt Range (2) and the Spiti regions (4). From both of these *Redlichia* has been obtained, but the detailed study of the Persian material shows a striking resemblance to the forms from China and Yunnan, while it is specifically different from the species from India; again, the Spiti area is characterized by numerous species of Ptychoparia, and although there appears to be much to be done in the revision of the generic names of this group of Trilobites it is clear at a glance that the Persian forms here referred to Anomocare and Chuangia are closely allied to the forms from China and Indo-China and have little or nothing in common with the Indian fauna.

The relationship with the Indo-China area is also shown in the presence of a *Billingsella* which is closely allied to, if not identical with, *B. tonkiniana* from that country.

If comparison is made with the known Cambrian exposures to the west, the first to be considered is that near the Dead Sea (10). The forms from that area, although referred to Anomocare, are of a quite distinct and highly specialized type. The Cambrian faunas of Europe have nothing in common with the Persian specimens.

The rock types suggest that the deposits were laid down in shallow water formed by the transgression of the Cambrian Sea over the south-west Persian Salt Group onto an old land mass, and it is to be expected that under these conditions rapid migration of fauna would take place, but that specialized faunas would develop in certain areas forming sub-provinces in the main zoological province.

This collection shows that south-western Persia belonged to the eastern Asiatic province in both Middle and low Upper Cambrian times, but the striking similarity of the fauna with that of Indo-China, and to a certain extent with that of China, is in marked contrast with its difference from the known faunas of India. It is considered that this is more likely to be due to a difference in age between the Persian and Indian horizons rather than to a difference of zoological province.

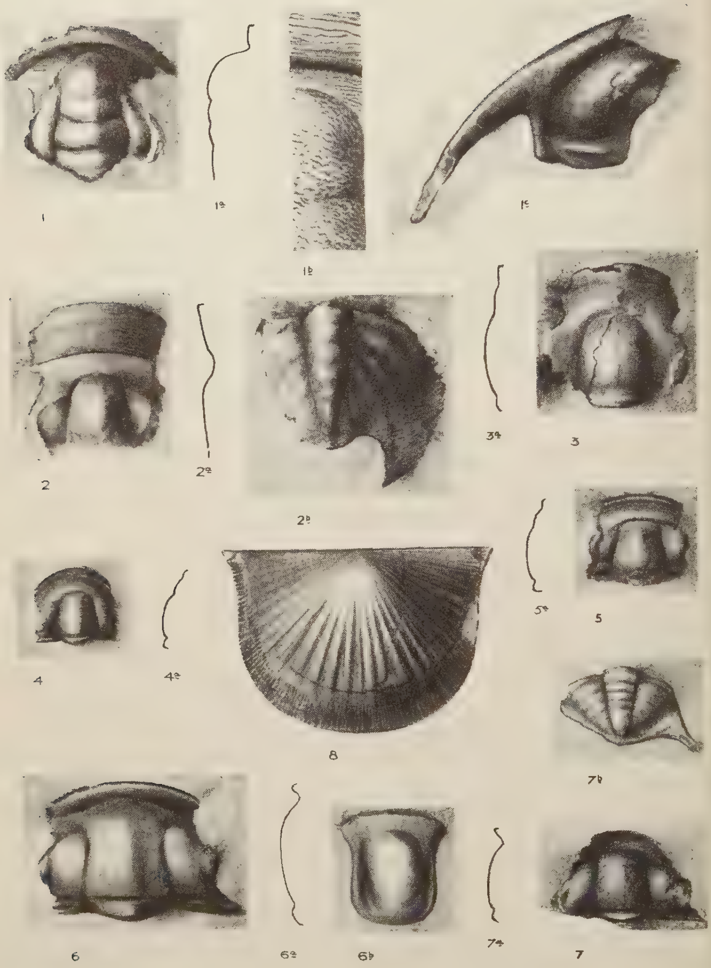
In this connection, it is interesting to note that Dr. J. A. Douglas (11) found that the Triassic fossils of Persia discovered by Messrs. Jennings and Gray agreed with those of south-eastern Asia and differed markedly from those of northern India.

(1) DAMES, W., in Richthofen, *Beiträge zur Paläontologie von China*, 1883.
(2) REDLICH, K. A. "Cambrian fauna of the Eastern Salt-Range," *Palaeontologia Indica*, New Series, vol. i, 1901.
(3) WALCOTT, C. D. "Cambrian faunas of China," *Proc. U.S. Nat. Mus.*, vol. xxix, 1905.
(4) REED, F. R. C. "The Cambrian fossils of Spiti," *Palaeontologia Indica*, Series xv, vol. vii, No. 1, 1910.
(5) MANSUY, H. "Etude géologique du Yun-nan oriental," *Mem. du Serv. Géol. de l'Indochine*, vol. i, fasc. ii, IIme part, 1912.
(6) WALCOTT, C. D. "Cambrian Brachiopoda," *U.S. Geol. Surv. Monogr.* li, 1912.
(7) —— *Research in China*, vol. iii, Carnegie Inst. Publ. No. 54, 1913.
(8) MANSUY, H. "Faunes cambriennes du Haut Tonkin," *Mem. du Serv. Géol. de l'Indochine*, vol. iv, fasc. ii, 1915.
(9) —— "Faunes Cambriennes de l'extrême-orient méridional," ibid., vol. v, fasc. i, 1916.
(10) KING, W. B. R. "Cambrian fossils of the Dead Sea area," GEOL. MAG., Vol. LX, 1923.
(11) DOUGLAS, J. A. *Quart. Journ. Geol. Soc.*, 1929.
(12) GREGORY, J. W. *The Structure of Asia*, 1929.

EXPLANATION OF PLATE XVII.

FIG.

1.—*Redlichia chinensis* Walcott. Fig. 1: cranidium No. JG/ZE/2986; 1*a*: profile of cranidium; 1*b*: enlargement of part of cranidium to show surface markings and pits; 1*c*: free cheek. No. JG/ZE/2987. Limestone of Kuh-i-Dinar.



E.T. TALBOT, del.

CAMBRIAN FOSSILS FROM PERSIA.

2.—*Anomocare dikellocephaloides* sp. nov. Fig. 2: cranidium, JG/ZE/821; 2*a*: profile of cranidium; 2*b*: pygidium. Limestone of Darreh Duzdan.
3.—*Anomocare persicum* sp. nov. Fig. 3: cranidium; 3*d*: profile of cranidium. Limestone of Kuh-i-Namak.
4.—*Anomocare megalurus* (Dames), JG/ZE/1461. Fig. 4: cranidium; 4*a*: profile of cranidium. Limestone of Kuhbanan.
5.—*Anomocare subquadratum* (Dames). Figs. 5 and 5*a*: cranidium and profile. Limestone of Kuh-i-Namak.
6.—*Chuangia nais* Walcott. Fig. 6: cranidium; 6*a*: profile, Brit. Mus., No. In 27687; 6*b*: hypostome B.M. No. In 27688. Limestone of Narghun.
7.—*Chuangia nais* Walcott. Fig. 7 and 7*a*: cranidium; 7*b*: pygidium Limestone of Kuh-i-Namak
8.—*Billingsella tonkiniana.* Mansuy. Dolomitic limestone of Kuh-i-Namak.

All Figures × 1½ dia. except Figs. 1*b*, 6, and 6*b*, which are 4 dia. All the figured specimens are preserved in the British Museum.

REVIEWS.

Mineralogy. An Introduction to the Scientific Study of Minerals. By Sir Henry A. Miers, M.A., D.Sc., F.R.S. Second edition, revised by H. L. Bowman, M.A., D.Sc. pp. xx + 658, with 729 figs. London: Macmillan & Co., 1929. Price £1 10*s*.

WHEN the first edition of this book appeared twenty-eight years ago it was hailed by reviewers in the mineralogical and geological periodicals of the day as a very welcome and long-needed work. Previous to the appearance of Sir Henry Miers' *Mineralogy*, students of the subject had access only to the smaller " Mineralogies " of F. Rutley and F. H. Hatch, and to the first-rate American text-book of E. S. Dana, then in its first edition. Since that time several other excellent text-books have appeared both in America and in Europe, but none could quite take the place of Sir Henry Miers' book as a clear and eminently readable treatise on general mineralogy. For some years, however, this book has been out of print, second-hand copies have been difficult to procure, and in consequence it may have fallen into disuse in Universities where it was a standard text-book. The new edition will be very welcome to those who learnt to appreciate the old one, and it can be strongly recommended to all serious students of mineralogy.

The original plan and most of the original text have been retained. Some additions, amounting to 74 pages, have been made to bring the book a little more up-to-date, and 63 figures have been added to the already excellent illustrations.

The additions include three simple and useful constructions for use with the stereographic projection, formulae giving the relations between the symbols of faces lying in a zone, and a note on electrical and magnetic properties of crystals, and on radioactivity.

In the chapter on optical properties of crystals the idea of the wave-surface has been introduced in addition to the Fresnel ellipsoid and the Indicatrix. The section on interference phenomena seen in parallel light has been rewritten and improved. The plates of an interference figure of orthoclase in convergent light, which were probably the first example of the use of three-colour collotype printing for reproducing interference figures, have been omitted, no doubt on account of expense.

Some additional information on isomorphism and on intergrowths and overgrowths, based on work of Mr. T. V. Barker, will be found in the chapter on chemical composition.

The very useful determinative tables at the end of the book have been reproduced with corrections and additions.

All these are minor additions to the main body of the original text, but more important additions have naturally been made to the portions dealing with crystal structure. The five-page appendix of the first edition on theories of crystal structure has been expanded by the addition of an entirely new chapter on the investigation of crystal structure by means of X-rays and by further explanations of the results of these investigations on the structure of diamond, graphite, blende, and wurtzite, and α- and β-quartz in the descriptions of these mineral species.

THE PHYSIOGRAPHICAL EVOLUTION OF BRITAIN. By L. J. WILLS, D.Sc., F.G.S. pp. 1–376 with 154 text-figures and 2 folding plates. London: Edward Arnold and Co., 1929. Price 21*s*.

THIS book supplies a very real need, and will assuredly have a warm welcome amongst many students of Geology. It gives an excellent account of the physiographic processes which have underlain and indeed controlled successive chapters in the geological history of Britain, often strengthened by reference to modern parallels. We think, however, notwithstanding the reasons put forward by Dr. Wills, that his arrangement is a mistake, as it undoubtedly detracts a great deal from the idea of continuous evolution to have this jumping forwards and backwards and it will, we are afraid, prove confusing to the student. Granting that the early part of the story is very incomplete, that does not seem an adequate reason for starting at the end of the Palaeozoic, since it is quite possible to show that the pieces of the early story gradually fit together and evolve into one harmonious whole. Moreover it is distinctly misleading to regard the Altaid orogeny as setting in during the latter part of the Carboniferous, when surely it was the dominant control throughout the whole of the deposition of the Lower Carboniferous, and was probably effective even earlier, when the Devonian Sea first invaded the Welsh estuary from the south.

Passing to matters of greater detail, we confess we had hoped that that much abused term "Atlantis" had passed into oblivion and been replaced by the Great Northern Continent, and frankly we deprecate its revival. The term Cuvette (horribly suggestive of a Channel crossing!!) seems unnecessary where Basin and sub-Basin can be used, and difficult to uphold even according to the definition given, since the irregularity in form of such areas of deposition is often as truly determined by folding as a normal basin, only that the folding being posthumous tends to run in various directions. The omission in the introduction of an adequate description of the significance of facies is unfortunate in view of its importance at several geological periods; it may for instance explain away several supposed non-sequences, and is in all probability the determining factor in the difference in the faunas of the Scotch and Welsh Cambrian, since it is certainly a control of as great importance as either a land barrier or a "deep".

It is good to see again Boswell's excellent diagrams illustrating diachronism, and showing so clearly that the divisional planes between lithological facies do not coincide with the planes bounding contemporaneous deposits. Dr. Wills has also been well advised in reproducing Lapworth's diagram of the main directions of folding in the British Isles (but surely from the B.A. *Handbook*, not the *Report* of the Birmingham meeting as stated in the footnote), and we could wish that his terminology might find general acceptance in this country, since it is so simple and so definite. In this connection it is to be regretted that Dr. Wills has not himself stressed more particularly in this book Bertrand's principle of the continuity of folding, for it has been very active throughout the evolution of Britain, and insistence upon it makes this evolution very clear. Thus in the Jurassic, whilst no new lines of folding are initiated, sedimentation is to a large extent controlled by rejuvenated (or posthumous) folding along Charnoid, Malvernoid and Armoricanoid lines. In this connection, too, one might have expected some reference to the name of Godwin-Austen. Section 5 dealing with the Alpine orogeny and the development of the present day conditions in Western Europe strikes us as particularly successful: this is not perhaps surprising since it embodies a good deal of the author's own work; in sections 6 and 7, which follow, the author is less happy and seems rather out of his depth, particularly in the chapter dealing with the Caledonides. Considerable confusion does, of course, exist on this subject, but it is not quite so bad as he makes out.

The earlier movements (whether of Pre-Cambrian age or no) result in the main from an impulse from the N.W., and were deep seated movements associated with regional metamorphism (depth metamorphism) and recumbent folding; the second, usually referred to as Caledonian, resulted mainly from an impulse from the S.E., and were relatively superficial with no constructive metamorphism, but commonly some diastrophism. These second movements fold the earlier recumbent folds, packing them on themselves and rupturing them in places. A third still later movement from the

N.W. again affects the folds of the second and may always be distinguished from the earlier movement from the N.W. by the diastrophic effects with which it is accompanied. Dr. Wills cannot quite get away from the old idea of lake basins for the deposition of the O.R.S., but surely the Caledonian orogeny must have produced many mountain chains running out seawards and thus giving rise to a ria type of coast-line; in the landward continuation of these rias the O.R.S. may well have been laid down in the way suggested by Barrell. A lake could at most have had but a temporary existence at the time of maximum humidity, and even then was probably continuous with the sea.

The book is well got up and the figures clear and good for the most part, with the exception of Fig. 30, where the Pennine axis ends with too definite a trend to S.S.E. so that the Nuneaton axis appears relatively too far to the W., giving no room at all for the important S. Staffordshire anticline. We are doubtful, too, if the Lake District fold is correctly indicated.

These criticisms refer for the most part, however, to matters of detail and must not be considered to weigh at all heavily against the merits of the book as a whole. It gives, as no other book recently published has given, a real meaning to stratigraphical geology, raising it from the dull plane of a bare record of facts to its proper level as a subject of fascinating interest.

G. L. E.

PRECIOUS AND SEMI-PRECIOUS STONES. By MICHAEL WEINSTEIN. Sir Isaac Pitman and Sons, Ltd. 7*s*. 6*d*.

THIS book for the general reader deals adequately with the definition and determination of the physical properties of gemstones. There follow descriptions of various precious and semi-precious stones. The last chapter, "Superstition and Gemstones," which could have been the most interesting in the whole book, is a dreary catalogue of ancient traditions.

The author is mistaken in supposing this book fills a gap, for it covers just the same ground as Herbert Smith's *Gemstones*. That Mr. Smith is Mr. Weinstein's inspiration, is suggested by the general arrangement of the book and many parallel passages, of which this example is typical :—

"From that unrecorded day when some scantily-clothed savage seeking for succulent food opened an oyster and found within its shell a delicate silvery pellet . . ." (H. S.)

"The surprise and delight of our unclothed forefathers when they discovered a beautiful gem in a shell instead of only an oyster may be easily imagined." (M. W.)

The style sometimes becomes very obscure ; to compute the value of a pearl, for example :—

"The pearl is first weighed in grains and this weight is squared.

The resultant figure called the ‘ base ’ or ‘ shilling base ’ is regarded as shillings. The ‘ base ’ value of the pearl is then ascertained and the shilling base is multiplied by the base assigned to the pearl.”

The book is marred by inaccuracies for which there is little excuse. “ Diamond developes electricity on heating,” p. 14. “ The crystal faces of diamonds are often curved and distorted owing to the tremendous pressure to which they have been subjected,” p. 29. “ The lack of dichroism in spinels distinguishes it very quickly from the garnets, rubies, and other stones,” p. 58.

Mr. Weinstein seems to have misunderstood the X-ray method of detecting cultured pearls, though his faith in its infallibility is unbounded. He says “ the nucleus can be seen in much the same way as a human bone may be seen in an X-ray apparatus ”. Actually the method is to compare Laue photographs, which are different for cultured and real pearls. Since a substance of any density can be used as a nucleus in a cultured pearl, it is clear that no method of detection dependent on differential absorption could be reliable.

THE GEOLOGY OF NORTH AYRSHIRE (Explanation of One-inch Sheet 22). Second edition. By J. E. RICHEY, M.C., B.A., E. M. ANDERSON, M.A., B.Sc., and A. G. MACGREGOR, M.C., B.Sc., with contributions from E. B. BAILEY, M.C., B.A., G. V. WILSON, B.Sc., G. A. BURNETT, B.Sc., and V. A. EYLES, B.Sc. Palaeontological Chapters by the late G. W. LEE, D.Sc., and R. CROOKALL, Ph.D. And an Account of the Soils and Agriculture by the late R. A. BERRY, Ph.D., F.I.C., E. M. MELVILLE, M.A., B.Sc., A.I.C., and C. LOUDEN, B.Sc., A.I.C., of the West of Scotland Agricultural College. Department of Scientific and Industrial Research. Memoirs of the Geological Survey, Scotland. Pp. viii + 417, with 10 plates and 42 figures. Edinburgh: H.M. Stationery Office, 1930. Price 10*s*. net.

THE interest of North Ayrshire is about equally divided between its stratigraphy and its igneous geology and petrography. This fine memoir, which replaces the short explanation of Sheet 22, published in 1871, is a rich mine of facts and theories for both stratigraphers and petrologists. Messrs. J. E. Richey and E. M. Anderson are chiefly responsible for the stratigraphy, Mr. Richey for the igneous geology, with however, numerous contributions from other Survey officers. Mr. A. G. MacGregor has dealt worthily with the remarkable igneous petrography; Mr. M. Macgregor has contributed the useful introductory chapter; Mr. G. V. Wilson has written the chapter on the Millstone Grit and its economic products; and Professor E. B. Bailey has generally supervised the preparation of the memoir. A special feature is a long and detailed chapter on the soils and agriculture of the area by the late Professor R. A. Berry and his co-workers of the West of Scotland Agricultural

College. Pedologists and agriculturalists (with, perhaps, the aid of some skilled interpretation) will find the material in this chapter of great interest and value. Chapters on the fossil faunas and floras respectively have been contributed by the late Dr. G. W. Lee and by Dr. R. Crookall.

The oldest rocks of the district are the Downtonian sediments, which are followed, with apparent conformity, by the Lower Old Red Sandstone, containing feldspathic sandstones, andesite and basalt lavas, and their tuffs. The Distinkhorn plutonic complex, consisting of granodiorite, quartz-diorite, and hypersthene-diorite, in a mass 3 miles long by 1 mile wide, cuts the Silurian and Devonian sediments to the south-east of Darvel, and is accompanied by a suite of porphyrite and felsite dikes and sills. It is surrounded by a broad zone of contact-metamorphosed sediments, including early dikes.

The most interesting feature of the metamorphism is the proof afforded that the later granodiorite has strongly altered the diorites into which it has been injected. A peculiar turbidity has been induced in the feldspars, altered ferro-magnesian minerals have been converted into metamorphic green hornblende, and the pyroxenes have recrystallised into fresh orthorhombic and monoclinic varieties. These observations are important because many diorites resent this fresh and recrystallised appearance. There may also be some resemblance here to the supposed metamorphic origin of the charnockite series.

The chief advances in Carboniferous stratigraphy that have been made in this memoir are: (1) The establishment of attenuation of the Lower Limestone Group towards the south-east as compared with its more complete development near Beith. The conclusion has been reached that the strata up to and including a portion of the Limestone Coal Group are locally absent in the south-eastern area owing to overlap against land composed of older Carboniferous and Upper Old Red Sandstone sediments. (2) Extraordinary variations in thickness of the Limestone Coal and Upper Limestone Groups have been detected in the neighbourhood of the Dusk Water and Inchgotrick faults, both of which run in a general east-north-east to west-south-west direction across the central part of the area, and throw to the north-west. It is suggested that both these faults were in intermittent movement during the deposition of the sediments. Remarkable local movements, fragmentation, and local unconformities in the Inchgotrick quarry are regarded as mainly earthquake effects produced by the jerky movement of the Inchgotrick fault.

Lavas, ashes, and intrusions of Calciferous Sandstone age occur in great variety and profusion in the northern and eastern parts of the area. A general sequence of lavas has been established, consisting of a Lower Group of macroporphyritic basalts followed by an Upper Group of microporphyritic basalts. In both groups flows of mugearite are occasionally encountered, whilst trachytic lavas and ashes are found locally in the Upper Group. A number of intrusions, chiefly plugs, occur within the trachytic belt.

This igneous series contains rocks of unusual petrographical interest and variety, and Mr. A. G. MacGregor, with the aid of numerous new chemical analyses, has made full use of his opportunities in describing them. For olivine-basalts and mugearites, the amended and simplified classification recently made[1] has been adopted with gratifying results. Trachybasalts (other than mugearites) and trachyandesites link the basalts to the trachytes, amongst which trachytes without quartz or nepheline, and phonolitic trachytes with a little nepheline, have been described. At the acid end the series terminates with quartz-bearing trachytes, rhyolites, and felsites. The Millstone Grit lavas, and their curious residual deposits of bauxitic fireclay are fully described by Mr. G. V. Wilson. The Coal Measures, to which the industrial development of North Ayrshire has been mainly due, are confined to the Kilmarnock Basin, in which the sediments dip from north and south to an east and west synclinal axis.

Numerous sills of Post-Calciferous Sandstone age occur within this region. These include the usual teschenite, picrite, alkali dolerite, and olivine-dolerite, etc., the detailed petrography of which is to be dealt with more fully in the forthcoming memoir on Sheet 14 to the south, where these rocks are more abundantly represented.

Finally the numerous dikes of Post-Carboniferous age are treated. They consist of andesites, quartz-dolerites, tholeiites of various types, crinanites, camptonites, and monchiquites. The tholeiites and their congeners (andesites, quartz-dolerites, etc.), trending north-west to south-east, undoubtedly represent the south-easterly continuation of the Mull Swarm, and link up with the great solitary dikes of the Border country and the north of England. On the other hand there is a great swarm of east to west dykes in the Irvine Valley which includes not only tholeiites, but also camptonites and crinanites. The age and affinities of this group are not yet certain.

A word of praise must be devoted to the excellent diagrams and maps in the memoir, which are more than usually explanatory and informative, and also to the thoroughness of the proof-reading, the reviewer (so far) only having been able to detect misprints on pp. 32, 112, and 222. The production of this work is indeed a credit to all concerned, and we are glad to see the price so relatively low. The memoir will prove of enormous value for geological teaching in the West of Scotland.

G. W. T.

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[1] A. G. MacGregor, "The Classification of the Scottish Carboniferous Olivine-basalts and Mugearites," *Trans. Geol. Soc. Glasgow*, xviii, pt. 2, 1928, pp. 334–60.

DAS EISZEITALTER: GRUNDLINIEN EINER GEOLOGIE DES DILUVIUMS. By P. WOLDSTEDT. pp. xv + 406, with 162 figures. Stuttgart: Ferdinand Enke, 1929.

BEFORE proceeding to discuss this excellent book, it may be permitted to ask a rhetorical question: "How long is Continental geological science going to be disfigured by that dreadful word *Diluvium* ?" Most happily it has long disappeared from Britain and America, and it is difficult to see why continental geologists do not adopt Pleistocene. This is no more un-German than Pliocene or Miocene, and as a matter of fact Diluvium only perpetuates a scientific absurdity: the attempt to correlate the drift with Noah's flood.

Dr. Woldstedt's book is, as the title indicates, an attempt to give a general account of the Pleistocene glaciations: it is not confined to Europe, though his description of this region is necessarily more detailed than that of other areas. The first eight chapters give an admirable general summary of the glacial phenomena of the present day and of the characteristics of formerly glaciated regions. There is a very good discussion of the problem of osar, eskers, and kames, in which it is concluded that the railway-embankment-like (eisenbahndammähnlich) osar and eskers are formed by englacial streams running in narrow channels, while the kames are due to broad sheets of material included in the ice. Many interesting details are also given of the topography of glaciated areas in North Germany and Denmark, not usually available to English readers in so convenient a form. It may be noted here that the literary style is very simple and lucid, with conveniently short sentences, and without the unnecessary grammatical involutions so beloved by many German writers.

In Northern Europe the author recognizes three principal glaciations, which he correlates with the Mindel, Riss, and Würm: he considers that indications of the Günz are somewhat uncertain. For these three, from below upwards, he adopts the names Elster, Saale and Weichsel (Vistula in English) originally suggested by Keilhack as an improvement on the usual German I, II, and III. English readers will turn with special interest to the correlation of the British glaciations with this series. This may be put in a condensed form as follows:—

1. Upper Boulder Clay = Weichsel.
2. Maximum Glaciation = Saale.
3. Arctic fresh-water bed = Elster.

It is suggested tentatively that the Günz is represented by the Chillesford and Weybourn Crags, a suggestion with which most British geologists will probably agree. The Cromer Forest Bed is correlated, also tentatively, with the pre-Elster Tegelenstufe of the Rhine Valley, while the position of the Cromer Till is left somewhat vague. This deposit is not mentioned by name.

The author's views on the Loess are of some interest: he divides it into four stages of formation, with three intermediate stages of weathering, and considers that these represent the whole of the compound glacial period in eastern Europe, Loess being formed during glaciations and denuded during the interglacials.

The book closes with a discussion of the causes of the Ice Age, in which the author reaches the not very surprising but eminently sensible conclusion that nobody knows anything about it. This is indeed one of the major problems of geology as to which we must await the judgment of the future, since all our present knowledge seems to be completely inadequate to afford any explanation.

R. H. R.

REPORTS AND PROCEEDINGS.

GLASGOW GEOLOGICAL SOCIETY.

13*th February*, 1930.

1. " Investigation of Faults by means of the Torsion Balance." By Dr. J. Phemister, H.M. Geological Survey.

Faults are of vital importance in mining fields, for they may represent the boundary beyond which productive working can be carried only after expensive drilling, or perhaps not at all; in certain oil fields, on the other hand, location of a fault is preliminary to sinking a well. There is usually a sudden small change in the force of gravity from one side of a fault to the other. Use is made of this fact in gravitational surveys and the method was illustrated by reference to the results obtained by H.M. Geological Survey, near Portobello, Edinburgh, where the Pentland Fault was traced for a quarter of a mile beneath a cover of raised beach and glacial deposits.

2. Dr. H. H. Read, H.M. Geological Survey, exhibited a suite of specimens from Central Sutherlandshire showing all stages in the permeation of various types of Moine Schists by granite juices.

GEOLOGISTS' ASSOCIATION.

7*th March*, 1930.

A. E. Trueman, D.Sc., F.G.S.: " The Lower Lias (Bucklandi Zone) of Nash Point, Glamorgan."

When describing the Lower Lias of Glamorgan (*Proc. Geol. Assoc.*, xxxiii., 1922, p. 245) the author established a sequence in the Planorbis and Angulata Zones, but gave few details as to the sequence in the Bucklandi Zone. This zone, which is over a hundred feet in thickness, consists of a monotonous series of nodular limestones with thin shale partings. Inland, these limestones are poorly exposed and along the coast they generally form the upper part of the steep cliffs, but they descend to the foreshore at Nash Point.

In that area, several rich faunas have been obtained. These indicate the subzones of *Metophioceras conybeari*, *Coroniceras rotiforme*, *Paracoroniceras gmuendense* and ? *Coroniceras bucklandi*. These subzones are much thicker than in Dorset; thus the *Metophioceras conybeari* subzone is 50 feet thick as compared with only 12 feet in Dorset. The local sequence in the *Coroniceras rotiforme* subzone differs somewhat from that observed by Dr. Lang in Dorset, a horizon with *Charmasseiceras* spp. occurring immediately below beds with abundant species of *Arnioceratoides*.

Some new forms of *Arnioceras*, *Arnioceratoides* and *Charmasseiceras* are described.

(WEALD RESEARCH COMMITTEE REPORT, NO. 9.)

A. A. Fitch, A.R.C.S., B.Sc.: "The Geology of Etchingham and Robertsbridge, Sussex."

The area described is in the Central Weald, and is essentially a syncline in structure, complementary to the Heathfield-Battle Anticline, the axis of which passes in the neighbourhood of Mountfield, to the south of the area described. The rocks exposed comprise the Ashdown Sand, Wadhurst Clay and Lower Tunbridge Wells Sand. The drainage is carried by the River Rother, and is controlled more by the fault lines than by the fold axes.

(WEALD RESEARCH COMMITTEE REPORT, NO. 11.)

G. S. Sweeting, D.I.C., F.G.S.: "The Geological Structure of the Ashburnham, Battle and Crowhurst Districts, Sussex, with notes on the Wealden Iron Ore."

This paper describes the geological structure of the Ashburnham-Battle-Crowhurst districts, Sussex, of which the main stratigraphical and petrological features were given on a previous occasion (*Proc. Geol. Assoc.*, vol. xxxvi). Structurally the area forms a segment of the southern flank of the Heathfield-Battle anticline and illustrates the type of subsidiary folding, also faulting, characteristic of this part of the Weald. The district is classical as one of the principal sites of the old Wealden iron industry, and some account of the ore and its exploitation is given.